

Ethanol, Citric Acid, and Lactic Acid Use Corn as a Feedstock

Industrial uses of corn in 1996/97 are expected to total 681 million bushels, up from the 642 million used in 1995/96. Ethanol production has rebounded from the low levels experienced in 1995/96. Markets are growing for citric and lactic acids, two organic chemicals usually derived from starch and sugar feedstocks.

Industrial uses of corn in 1996/97 are expected to total 681 million bushels, up from the 642 million used in 1995/96 (table 3). In 1997/98, industrial uses of corn may account for 736 million bushels, a further increase over this crop year. Industrial uses will account for 7 percent of the supply of corn in 1996/97, the same percentage as in 1995/96 when supplies were lower, and a similar proportion is expected in 1997/98.

Corn used to produce ethanol in 1996/97 increased 10 percent from a year earlier. In 1995/96, ethanol producers were caught between higher costs for inputs, moderate increases in coproduct prices, and stable prices for competing products, which limited their ability to raise ethanol prices. Thus, many ethanol producers suspended operations to do maintenance on their plants. Corn used for ethanol production in 1997/98 is expected to increase from 1996/97 as ethanol firms continue production with prices competitive with other oxygenates.

In 1996/97, corn used for manufacturing alcohol was about the same as the previous year. In 1995/96, about 60 million bushels of corn were used for manufacturing alcohol, up from 36 million in 1994/95. Even with tight supplies of corn in 1995/96, higher prices for industrial alcohol relative to fuel alcohol kept corn use strong. In 1997/98, corn used for manufacturing is expected to be about the same as in 1996/97.

Corn used in industrial starch production in 1996/97 will likely be about the same as the 186 million bushels used a

year earlier. In 1995/96, corn used for starch production was down 3 percent from the 192 million bushels used in 1994/95. As producers passed along the higher costs of corn in 1995/96, their buyers apparently found alternative products that were less expensive. Corn prices in 1997/98 are expected to be down from a year earlier and corn use for starch production will likely increase. Industrial starch prices and corn use are not highly correlated because starch users and starch producers tend to contract ahead to meet their needs (figure 4).

Ethanol Production Rebounds Somewhat

The financial squeeze ethanol producers experienced in 1995/96 has dissipated as corn prices have dropped and prices of gasoline and methyl tertiary butyl ether (MTBE) have increased. Blending margins for ethanol have greatly improved from last summer when the wholesale price of gasoline was almost 28 cents per gallon less than that for ethanol, excluding the 54-cents-per-gallon ethanol tax incentive. Ethanol prices are strongly influenced by gasoline prices because a large proportion of ethanol is blended into regular gasoline as an octane enhancer and fuel extender. In the spring of 1997, the price difference had narrowed to about 6 cents per gallon. Ethanol also has been competitive with its main rival, MTBE, in oxygenated-fuel-mandated areas because MTBE prices have been on an upward track until recently.

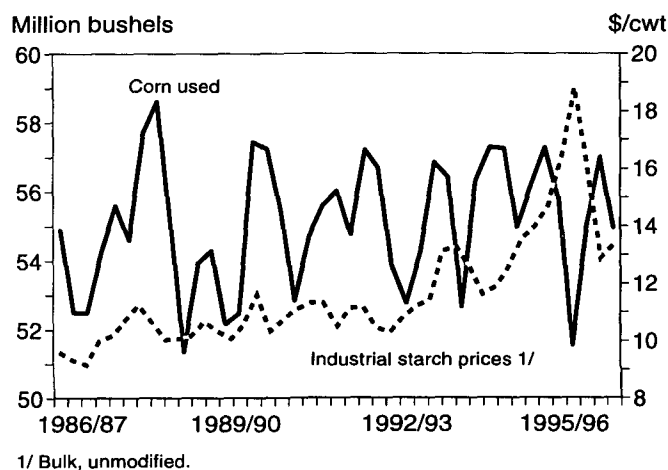
While ethanol production is increasing because of more favorable economics, it has not rebounded to the peak level

Table 3—Industrial and food uses of corn, 1990/91-1997/98

Marketing year 1/	HFCS 2/	Glucose and dextrose 2/	Cereals and other products	Starch			Alcohol			Total Industrial use 4/
				Food uses	Industrial uses	Total 3/	Bev- erage	Manu- facturing	Fuel	
Million bushels										
1990/91	379	200	114	33	186	219	54	81	349	616
1991/92	392	210	116	34	191	225	58	103	398	692
1992/93	415	214	117	33	185	218	51	80	426	691
1993/94	444	223	118	33	189	223	55	55	458	702
1994/95	465	231	118	34	192	226	64	36	533	761
1995/96	485	235	118	33	186	219	65	60	396	642
1996/97 5/	505	240	120	39	186	225	70	60	435	681
1997/98 6/	530	245	136	39	191	230	73	60	485	736

1/ Marketing year begins September 1. 2/ High fructose corn syrup (HFCS), glucose, and dextrose are primarily used in edible applications, such as food and health-care products. 3/ Industry estimates generally allocate 85 percent of total starch use to industrial applications and 15 percent to food applications. 4/ Industrial uses of starch and manufacturing and fuel alcohol. 5/ Preliminary. 6/ Forecast.

Figure 4
Corn Used in Starch Production and Industrial Starch Prices, Quarterly



of 1995 (figure 5). From January to June 1997, ethanol production has averaged 81,000 barrels per day. In comparison, U.S. MTBE production averaged 187,000 barrels per day during the same period. In addition to domestic production, significant amounts of MTBE are imported, particularly to the West Coast. About 435 million bushels of corn are estimated to be used for ethanol production in the 1996/97 crop year. With this amount of corn, plus sorghum and other feedstocks, ethanol production is expected to total 28.6 million barrels in 1996/97, up from 24.8 million barrels in 1995/96.

Ethanol producers are apparently still trying to regain the market share they lost in octane and oxygenated fuel markets when corn prices reached record levels during 1995/96. The loss cannot be overcome immediately, because producers must reestablish long-term contracts with blenders. After last year's extended maintenance shut downs, ethanol producers found many petroleum firms already had committed to MTBE for the winter oxygenate season. In May 1997, stocks of ethanol were 166 percent of a year earlier, suggesting by the winter oxygenate season, petroleum firms will find plentiful supplies of ethanol for blending. Another reason for the slow rebound is that a robust market for beverage exports has diverted production from fuel-grade alcohol.

Demand Is Growing for Citric and Lactic Acids

Many organic chemicals can be derived from starch and sugar feedstocks, including citric and lactic acids. These two organic acids have multiple uses, both food and industrial, and have growing markets. Though both chemicals can be derived synthetically, biobased production methods are the main source of these commodities. Both citric and lactic acid are derived by microbial fermentation of a carbohydrate feedstock. Either crude sugars, such as sucrose or molasses, can be used or the sugar feedstock can be derived from any

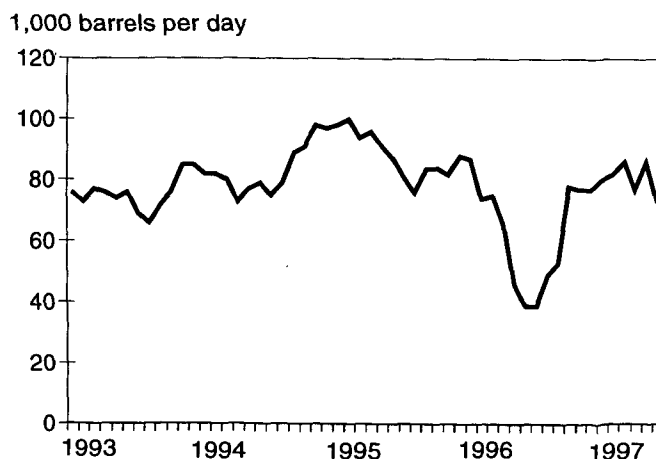
starch-rich crop, including potatoes, sweet potatoes, wheat, barley, rice, and corn.

Citric acid is the largest volume organic acid produced by fermentation, accounting for approximately 85 percent of the fermentation-based organic acid market (6). In addition to wide use as an acidulant in the food and beverage industry, it also is used in a variety of industrial and pharmaceutical applications as an acidulant, dispersing agent, sequestering agent, water-conditioning agent, detergent builder, and cleaning agent. In the United States, about 45 percent of citric acid is used in the beverage industry, 23 percent in foods, 20 percent in detergents, 6 percent in pharmaceuticals, and 6 percent in other chemical processing industries.

Output in the three main producing regions of Western Europe, the United States, and China, which together account for about 88 percent of world capacity, was estimated to be over 1.2 billion pounds in 1994 (1). With steady growth rates in citric acid markets in recent years, production in these regions in 1997 could be as high as 1.3 to 1.7 billion pounds. However, another estimate puts the world market at less than 1 billion pounds annually (6). Estimates on the value of the world market also differ, ranging from less than \$1 billion to as high as \$2 billion annually.

In the United States, citric acid production is estimated to be about 475 million pounds annually, with an industrial capacity of about 490 million pounds (3). U.S. domestic demand for citric acid is assessed to be between 400 and 450 million pounds per year, with a market value of about \$340 to \$380 million. Continued market expansion is expected due to growth in traditional and new uses. With strong growth, improved product value in specialty applications, and increased production capacities, the market for U.S.-produced citric acid could reach \$650 to \$750 million by the year 2005.

Figure 5
Monthly Ethanol Production



Source: U.S. Department of Energy, Energy Information Administration.

The three major U.S. producers are Archer Daniels Midland Company (ADM); Cargill, Inc.; and Haarmann and Reimer Corporation (H&R), a subsidiary of Bayer. Currently, most citric acid in the United States is produced via submerged (deep-tank) fermentation of corn-derived glucose or dextrose. Other carbohydrate sources, such as potato, sweet potato, and wheat starch, may be utilized, but on a smaller scale due to their higher cost relative to cornstarch. H&R, the only major producer not vertically integrated back to feedstocks, is looking to sell its citric acid plant. ADM, on the other hand, recently announced plans to build a new bioproducts plant in Cedar Rapids, Iowa, that will produce citric acid, lactic acid, lysine, xanthan gum, and glycerine. In recent years, vertical integration and large facilities, which take advantage of economies of scale, have become very important to the profitable operation of fermentation facilities.

Another organic acid that has the opportunity for expanded use due to developing industrial applications is lactic acid. It is produced by either fermentation of a carbohydrate feedstock or synthetically by hydrolysis of lactonitrile. About 85 percent of lactic acid demand is for food and food-related applications, particularly as a general purpose food additive and to produce emulsifying agents for use in baked goods. Lactic acid also is used in foods and food preparation as an acidulant, flavor enhancer, preservative, texture modifier, antibacterial agent, and preservative for meat carcasses. Some examples of industrial applications, which currently account for about 15 percent of lactic acid use, include use as an ingredient or intermediate in the manufacture of numerous chemicals, a mordant in dyeing wool, a pH balancer in shampoos and soaps, and as the building block for polylactic acid (PLA), a biodegradable polymer (for information on PLA, see the September 1995 issue of this report).

Much of the lactic acid used in the United States has traditionally been imported from Europe, although U.S. production is on the rise. ADM is the largest U.S. producer, followed by several other companies such as Cargill, A.E. Staley Manufacturing Company, and Chronopol, Inc. Total U.S. capacity is estimated to be near 40 million pounds per year, although this will likely rise as companies expand capacity and form joint ventures to build new plants. For example, Cargill has entered a joint venture with the Purac

Group, a subsidiary of the Dutch food multinational CSM, to produce lactic acid at a new plant being built in Blair, Nebraska. Purac is the largest producer of lactic acid in the world, with plants in Europe, South America, and the United States.

Although the bulk of the market for lactic acid is fairly mature and slow-growing, newer applications, such as the manufacture of biodegradable polymers, will likely increase lactic acid demand. Current U.S. demand for lactic acid is estimated at about 55 million pounds and total world demand near 150 million pounds (2, 4). Assuming lactic acid is worth an average \$1.15 per pound, U.S. and world markets would be valued at approximately \$63 million and \$173 million, respectively. These values will likely rise as the use of new lactic acid products grows and production technology improves. Conservative estimates have the market growing 3 to 5 percent annually (5), while higher estimates put the range at 8 to 10 percent annually. [Industrial uses of corn: Allen Baker, ERS, (202) 219-0360, albaker@econ.ag.gov. Ethanol: Roger Conway, OENU, (202) 219-1941, rkconway@econ.ag.gov, and James Duffield, OENU, (202) 501-6255, duffield@econ.ag.gov. Citric and lactic acids: Charles Plummer, ERS, (202) 219-0717, cplummer@econ.ag.gov]

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