The Citric Acid Industry

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The Citric Acid Industry
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1. Introduction

Citric acid is an organic, colorless, odorless acid with a unique molecular structure and a strongly acid taste. It exists in crystal and salt forms. Because it is a natural acid, it is healthy to be used as a food additive.

Usage

The importance of citric acid results from its several uses:

1. It is used as food additive (acidity, antioxidant) in many food industries such as soft drinks, confections, sausages, and dairy products.
2. It is used for the preparation of citrates and flavoring extracts.
3. It is used as detergent (cleaning and polishing stainless steel and other metals).

Technology development

There are three methods for the production of citric acid:

1. It will be extracted from citrus fruits (lemon, lime, and pineapple).
2. It will be produced through the chemical synthesis of calcium citrate.
3. It will be produced through the mold fermentation of carbohydrates and the deep fermentation of molasses.

Applying the first technology to produce citric acid is very expensive. Therefore, the second method was used in the United Kingdom in the early 19\textsuperscript{th} century to produce citric acid. However, the Italian monopoly of calcium citrate and its high prices provided an incentive to discover a new cheaper method. Accordingly, in 1917 an American chemical scientist discovered the ability of producing citric acid by mold fermentation (aspergillus
The Pfizer fermentation use in Europe began in the 1930s in a factory in the United Kingdom. Then, plants using sugar beet molasses fermentation started production in Germany, Belgium, and Czechoslovakia. Accordingly, Pfizer made many advances such as submerged cultures, higher-yielding yeast strains, and the substitution of glucose for sucrose. As a result, the Pfizer deep fermentation process became the standard of the industry in the 1980s. Moreover, the citric acid production from sweet potatoes or cassava was applied in China in the early 1970s.

2. The actors of the citric acid industry

Figure 1 shows the agents of the citric acid chain. They can be input suppliers, farms, processing units, wholesalers, retailers, importers, exporters, and consumers.

2.1. Input suppliers

Input suppliers are responsible for the delivery of farm inputs both in material and in financial form.

2.2. Farms

The farming system related to the citric acid industry consists of the citrus fruit producers, the sugar beet producers, the corn producers, and the potato producers. They have the tendency to integrate with the processing units in order to avoid risk, to reduce cost, and to offer the required quantities and qualities in time.
Figure 1: Flow chart of the citric acid chain
2.3. Processors

The processors are the sugar plants and the citric acid plants.

**Sugar plants**

They are responsible for transforming sugar beet to sugar, molasses, and fodder by-product. They tend to corporate strongly with the farmers in order to get the best quality of sugar beet. Thus, the goal is to achieve integrated sugar industry.

**Citric acid plants**

They are responsible for adding form utility to citrus fruits, molasses, and corn. Thus, they can transform these products to citric acid crystals, citric acid salts, alcohol, fructose, dextrose, glucose, and fodder. They have to develop value-added products that will improve their competitive positions in the market place. The main citric acid players are Archer Daniels Midland company (ADM), Cargill corporation, Bayer AG, Hoffmann-La Roche AG, Jungbunzlauer AG, and the Chinese firms.

**Archer Daniels Midland Co.**

ADM is the largest publicly traded agribusiness company in the United States and the second largest in the world. It has four major product divisions: oil seed products, corn starch products, bio-products, and other grains. The corn starch division includes citric acid, fructose, and other products. ADM had enjoyed a long period (1986-1996) of rapid growth, diversification, and profitability because ADM’s earnings per dollar of sales were about double of those earned by most agribusiness firms and because these earnings were quite variable. Up to 1995, ADM’s net sales increased by 10.1% per year. In 1995, ADM net sales were $12.7 billion. In 1995-1996, the years most affected by price fixing, net annual earnings jumped from $500 million to $794 million.
Cargill Corporation

Cargill is the world’s largest agribusiness company. In 1986, Cargill had sales of $32 billion (four times the size of ADM’s total sales). By 1999, Cargill total sales were $46 billion. It employs 81,000 people who work at 1000 locations (plants, warehouses, grain elevators, offices, …) in 65 countries. The company assembles, transports, stores, sells, and manufactures bulk grains, oil seeds, meats, salt, steel, and other basic commodities. Moreover, in addition to its wet milling business and following ADM’s lead, Cargill had invested heavily in a couple of huge corn refineries that made starch, oil, sweeteners, and other products like high fructose corn syrup. Like ADM, Cargill began to explore opportunities to utilize its large supplies of cheap corn sweeteners to make farther-processed, high-value-added agrichemicals by means of advanced fermentation technologies. One of its first biotechnology ventures was citric acid. The production of citric began in 1991, and after several expansions of capacity in the early 1990s, Cargill became a strong second in the U.S. industry after ADM.

Bayer AG

It is from the world’s largest chemical companies. Bayer, now headquartered in Germany. In 1954, Bayer made its first investment in the United States. One of its largest foreign investments was the acquisition of Indiana-based Miles Laboratories in 1978. Among Miles assets were two citric acid plants that gave Bayer half of the U.S. plant capacity for citric acid and about 40 percent of market sales. One of Miles subsidiaries was Haarmann & Reimer which marketed citric acid. Its U.S. holding company became Bayer Corporation. Later, Bayer became the sole producer of citric acid in Latin America, with three or four small plants there, some of them joint ventures.
Hoffmann-La Roche AG

It is a Swiss holding company. Roche has been focused on nutritional and pharmaceutical products from its beginning in the late 19th century. Later, its extensive R & D resources were applied to chemical synthesis. In the 1990s, Roche directed its capital investments toward biotechnology ventures. In 1997, its global sales achieved $12.7 billion and its employment was 51,600 persons. Almost two thirds of its sales consist of pharmaceuticals, but it was also a world leader in flavors, fragrances, vitamins, carotenoids, and genetic-engineering products.

Jungbunzlauer AG

It had one of the highest market shares because it was highly specialized in making citric acid. In 1895, this company began its investments in a alcohol distillery built in Jungbunzlau, Bohemia. Then, in 1962 Jungbunzlauer diversified the production into citric acid. Later, Jungbunzlauer made a large investment in a second citric acid plant located in Germany. Moreover, in 1990 it began to build a very large citric acid facility in France. The company also invested heavily in upgrading and expanding its Austrian and German plants. These projects raised Jungbunzlauer’s production capacity to 310 million pounds by 1993 (equal 20 percent of the world’s total). By 1994, its total capacity reached 460 million pounds (no further expansion). By 1997, the total employment in both its German and Austrian plants was about 428 employees and the total sales were about $300 million. With its French plant the European total employment will reach 1000 employees.

Chinese producers

It is a very rapid growing production. The production is characterized by low quality and low prices. However, in spite of the low quality, the produce is extensively export
oriented. In 1989, Chinese citric acid capacity was about 150 million pounds. In 1993, it reached 360 million pounds, and in 1996 the national capacity amounted to 660 million pounds. This causes a threat for the other major citric acid producers.

2.4. Wholesalers

They perform the functions of wholesaling. They can be both for raw products and for processed products. They are responsible for the distribution of citric acid related products to retailers and other industries such as detergents, confections, meat processing, soft drinks and dairy.

2.5. Retailers

They perform the functions of retailing in order to distribute citric acid related products to their end-users.

2.6. Importers

They import citric acid crystals and salts from rest of the world and distribute them to the wholesaling and retailing channels.

2.7. Exporters

They export citric acid products to the rest of the world.

3. Market size and growth

Total indicators of market size are the industry capacity, production, product demanded or consumed, and sales. Table 1 shows the development of citric acid consumption in The U.S. and Canada, in Europe, and in the total world. Figure 2 depicts these trends. From the table it can be elicit that U.S. and Canadian consumption of citric acid amounted for about 44% of global consumption in 1989 and accounted for about 30% in
2000. This means a declining market according to global demand. Europe was the second largest market,
Table 1: Global Consumption of citric acid

<table>
<thead>
<tr>
<th>Year</th>
<th>1989</th>
<th>1995</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>World consumption</td>
<td>725</td>
<td>1600</td>
<td>2300</td>
</tr>
<tr>
<td>U.S. and Canada</td>
<td>320</td>
<td>500</td>
<td>690</td>
</tr>
<tr>
<td>Share%</td>
<td>44.1</td>
<td>31.3</td>
<td>30.0</td>
</tr>
<tr>
<td>Europe</td>
<td>339</td>
<td>555</td>
<td>700</td>
</tr>
<tr>
<td>Share%</td>
<td>46.8</td>
<td>34.7</td>
<td>30.4</td>
</tr>
</tbody>
</table>

Figure 2: Global consumption of citric acid
accounted for 47% in 1989 and about 30.4% in 2000. This means that the global demand is increasing in the rest of the world.

4. The structure of production

It is to differentiate between the North American Market and the Global Market.

The North American Market

Table 2 gives an overview about the U.S. market shares of leading citric acid suppliers.

Table 2: U.S. market shares of leading citric acid suppliers %

<table>
<thead>
<tr>
<th>Sources of supply</th>
<th>1988</th>
<th>1995</th>
<th>1998</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>U.S. Manufacturing capacity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bayer/Haarmann &amp; Reimer</td>
<td>42</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>Pfizer or ADM</td>
<td>42</td>
<td>34</td>
<td>40</td>
</tr>
<tr>
<td>Cargill</td>
<td>0</td>
<td>30</td>
<td>29</td>
</tr>
<tr>
<td>Tate &amp; Lyle/A.E.Staley</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td><strong>Subtotal of Top 5 Companies</strong></td>
<td>94</td>
<td>97</td>
<td>90</td>
</tr>
<tr>
<td><strong>Total Supply</strong></td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: John M. Connor, Global price fixing, 2001

Until 1989, the production of citric acid was a duopoly. The two rivals were Pfizer, Inc (the oldest American manufacturer) and Miles Laboratories. Each of them produced
slightly more than 40% of the U.S. supply. Pfizer North Carolina (built after closing the original Brooklyn plant) had a capacity of 80 million pounds per year. In addition, he operated two small citric acid plants in Canada and Ireland. Miles Laboratories, located in Indiana and owned by Bayer Corporation, was nearly a twin of Pfizer. It operated two plants in Ohio. Pfizer and Miles each had U.S. sales share of about 38% in 1988.

In 1990, ADM entered the industry by purchasing Pfizer’s Irish and North Carolina plants with a capacity of about 120 million pounds and by purchasing 40 million pounds of citric acid for three years from Pfizer Groton plant. Thereafter, ADM became the largest citric acid producer by expanding the North Carolina plant capacity to 220 million pounds.

Also, in 1990, Cargill (the largest U.S. agribusiness firm) began the production of citric acid in its existing corn wet milling plant at Iowa. This plant required about 25 to 30 new employees. Its designed capacity is about 55 million pounds. The capacity of this plant was expanded to 80 million pounds in 1991 and to 160 million pounds in 1993.

Accordingly, Pfizer exited the industry after he was the leader for about 110 years. Moreover, Bayer reduced its capacity to 12%. Thus, ADM occupied the first place with 40% share and Cargill had the second place with 29% share. Following this trend, the industry entered a new stage because both companies are known for their aggressive and growth-oriented tactics. They were also the two largest manufacturers of dextrose and other corn sweeteners.

The importers in this market had a sales share of about 23% in 1988. The two largest importers were Hoffmann-La Roche (operated a large citric acid plant in Belgium) and the more specialized Jungbunzlauer (operated three large facilities in Germany, France, and Austria). The other importers were from different countries (China, Italy, and Israel).
Table 3 shows the global capacity shares of leading citric acid suppliers. In 1988, U.S. manufacturers had a share of 32%, Europeans had a share of 40%, and Asians had a share of 22%. In 1998, the U.S. share decreased to 20%, the European share decreased to 38%, and the Asian share increased to 39%.

Table 3: Global capacity shares of leading citric acid suppliers %

<table>
<thead>
<tr>
<th>Sources of supply</th>
<th>1988</th>
<th>1996</th>
<th>1998</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>U.S. Manufacturers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bayer/Miles</td>
<td>16</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Pfizer</td>
<td>16</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cargill</td>
<td>0</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Archer Daniels Midland</td>
<td>0</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Tate &amp; Lyle/A.E.Staley</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td><strong>European Manufacturers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hoffmann-La Roche</td>
<td>9</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Jungbunzlauer</td>
<td>15</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td>Biocor</td>
<td>6</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Bayer (outside U.S.)</td>
<td>10</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Palma Group</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>Asian Manufacturers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: John M. Connor, Global price fixing, 2001
The U.S. suppliers are Bayer/Miles, Pfizer, Cargill, Archer Daniels Midland, and Tate & Lyle/A.E. staley.

Bayer was the leader of the industry in 1989. It acquired Miles Laboratories in 1978. Bayer controlled about 230 million of citric acid plant capacity in 1989-1990. It acquired two plants in the United States, one in England, and joint-ventures in Mexico, Columbia, and Brazil. Its share decreased dramatically in the mid 1990s because there was no capacity expansion.

The European manufacturers are Hoffmann – La Roche, Jungbunzlauer, Biocor, Bayer (outside the U.S.), and Palma Group. They were export oriented firms.

European third largest manufacturer in the early 1990s was Hoffmann – La Roche. However, he did not expand his capacity too much.

By 1993 and for the rest of the 1990s, the leading producer in the world was Jungbunzlauer with its plants in Austria, Germany, and France. In 1991, it began to invest in a series of Asian joint-ventures to produce citric acid.

The fastest growth in production and in consumption was occurring in Asia, particularly in China. In 1989, Chinese citric acid capacity was about 150 million pounds, or about half as large as U.S. capacity. By 1996, Chinese production capacity had surpassed that of the United States, and by 2000 Chinese and European plants are expected to be equal size. Half of the Chinese production of citric acid was exported at prices substantially below those in Europe or North America. These low prices reflected both low qualities and low costs. Thus, China was seen as a looming threat to existing western manufacturers, especially European exporters.
5. The citric acid cartel and conspiracy

International trade provides information that helps in understanding the operations and the economic impacts of the global dimensions of the citric acid conspiracy. Citric is a storable commodity sold at a price high enough to justify being shipped internationally. As soon as the price differences between two continents widen to at least five or ten cents per pound, there is sufficient profit incentive for manufacturers or wholesalers to sell abroad. When a group of sellers tries to form a purely national price-fixing conspiracy, unless trade barriers exist, the sellers are limited in their ability to raise prices because at some level imports will flood the national market. Therefore, there was an incentive to build a cartel in order to practice a price-fixing scheme. The members of the cartel are ADM, Hoffmann-La Roche, Bayer, Jungbunzlauer, and Cargill. In 1991, the conspiracy began to raise prices in agreement with Cargill. From 1993 to 1996 the prices were fixed by $0.85 per pound in order to realize high profit.

The citric acid cartel controlled at most two thirds of the world’s supply of citric acid. Even with Cargill’s passive acceptance on the cartel’s pricing decisions, the Chinese producers appeared ready to spoil the cartel’s effectiveness because of their rapid growth and export expansion.

The cartel had the following economic impacts:

Price effects

When the G-4 (the members without Cargill) began meeting in 1991, they made agreements to raise their list prices globally. The monopoly power of the cartel raised prices above competitive levels and made price movement overtime immune to the forces of supply and demand. This caused an income transformation from buyers to sellers.
Production effects

The production was affected by the volume quotas allocated to each member of the G-4. Moreover, capacity expansions were slowed down. The four cartel members expanded capacity by about 20 percent from 1993-1997, whereas all other producers of citric acid in the world expanded by 67%.

Effects on international trade

The pattern of trade among nations was notably altered by the cartel’s operations. In the United States, just before the cartel was launched the drop in citric acid prices surrounding Cargill’s entry in 1990 caused a long-term upward trend in imports to be reversed. At the same time, the vast expansion of capacity created production in excess of domestic needs and prices favorable to a marked jump in exports. However, during the heyday of the cartel, the brief export surplus turned to a huge export deficit for the United States. The deficit was much larger than would have occurred in the absence of the cartel. In addition, there is some evidence that the cartel divided export markets between the European and North American producers and extended their power by price discrimination among destinations for exports.

Trade distortion

Although the cartel’s manipulation of prices was probably the main reason for the increase in the overall export gab, there may have been formal and informal restraints on export quantities as well.

Looking simply at U.S. exports, there is some support for the idea that U.S. producers forbade exporting to areas historically supplied by Bayer and Jungbunzlauer from their European plant locations.
Geographic price discrimination

As a rule, a monopolist can make more money by charging different prices to different customers than by uniform pricing. Whether the cartel took further advantage of its market power by pricing discriminately across export destinations is not clear in the citric acid case. However, there is evidence that there is price discrimination between Canada and Western Europe. Moreover, exports to Mexico, Australia, and New Zealand followed the low-priced Canadian pattern, whereas exports to most Latin American destinations resembled the Western European pattern of prices. Also, what is clear is that the variation in export prices across export destinations was much less after the cartel’s break-up than during the conspiracy period.

The customer overcharge

“The overcharge is conceptually identical to the extra profits generated for all sellers in the affected market, save for any extra costs incurred by sellers in operating the cartel. Note that that the overcharge essentially equals the additional profits of all cooperating suppliers in the market, not just those that were in the cartel”. The implied overcharge varies from $161 to $309 millions.

6. Conclusions

1. The citric acid cartel was able to be formed and to operate undetected for three or four years because its members were leading firms in highly concentrated, homogeneous – product oligopolies with substantial entry barriers into the relevant market.

2. The effectiveness of the cartel came about in spite of the significant differences in geographic location and business cultures.
3. In the late 1990s, there were ample signs that the world citric acid industry was becoming less concentrated, while the producers that had been members of the conspiracy continue to announce expansion of capacity in their home markets in North America and Western Europe.

References
