Citric Acid

$C_6H_8O_7$

D Direct Use Chemical

(liquid or solid)

Inputs to Manufacturing Process:
Substrate (corn, other source of glucose)

% of Total Domestic Consumption Attributed to Water Sector:
Less than 5%

Product Family:
Corn Substrate

CAS No.: 77-92-9

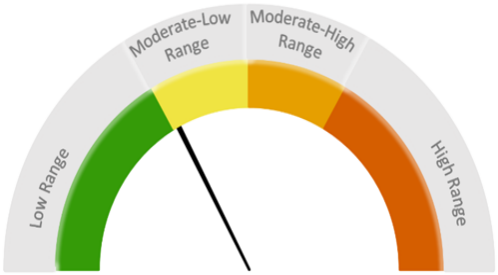
Derivative Water Treatment Chemicals:
None

Understanding Chemical Supply Chains
Map of Suppliers & Manufacturers

Shelf Life:
24+ Months

RISK OF SUPPLY DISRUPTION (Assessed in 2022)

RISK RATING: Moderate-Low



RISK DRIVERS

Production of citric acid depends on fermentation of a substrate, most commonly corn. Recovery and refinement of crude product may utilize one of three methods, one common method requiring calcium hydroxide and sulfuric acid. Domestic manufacturing has decreased over the past 20 years, and demand is increasingly met through imports.

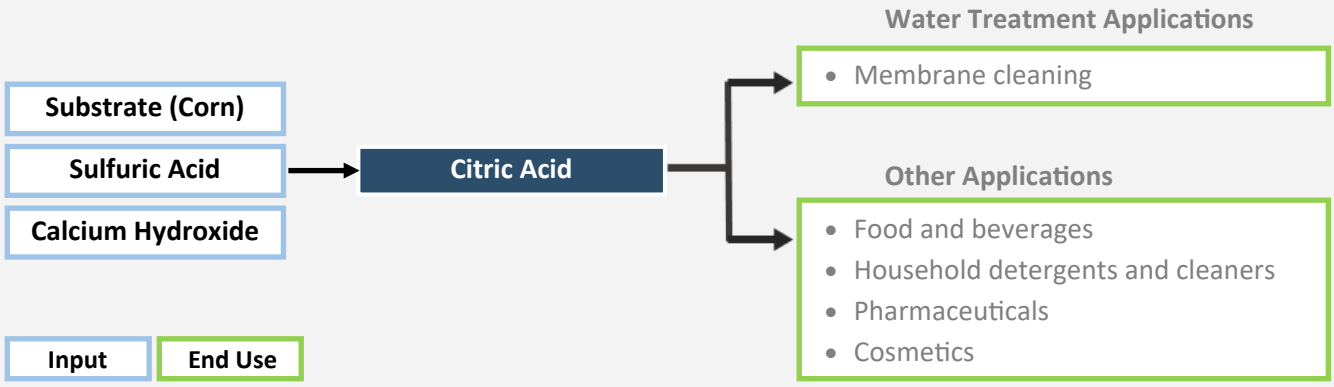
RISK PARAMETERS

Criticality: High. Essential and widely used for membrane cleaning.

Likelihood: Moderate-Low. Significant price increases, but no history of supply disruptions between 2000 and 2022.

Vulnerability: Moderate-Low. Domestic manufacturing is limited and meeting domestic demand depends on imports.

MANUFACTURING PROCESS



DOMESTIC PRODUCTION AND CONSUMPTION, AND INTERNATIONAL TRADE

Domestic Manufacturing Locations (2015):
11, distributed throughout the U.S.

International Trade (2019)

Primary Trading Partner (Imports): Thailand

Primary Trading Partner (Exports): Canada

Domestic Consumption (2015):
96 M kg

- Domestic Production (32 M kg)
- Imports for Consumption (75 M kg)
- Export of Domestic Production (12 M kg)

EPA

Product Description

Manufactured citric acid ($C_6H_8O_7$), an organic acid, is one of the most common additives in food and beverage products across the world. Citric acid is produced almost exclusively through microbial processes, utilizing a substrate and strain of mold or yeast.

Use in Water Treatment

Citric acid is used directly in water treatment for membrane cleaning.

Use as a Precursor to Other Water Treatment Chemicals

Citric acid is not used to manufacture other water treatment chemicals.

Other Applications

Citric acid has a wide range of applications, most commonly in food and beverage production as a flavoring, preservative, and acidulant. It is also commonly used in formulating cleaning agents, pharmaceutical, and personal care products (NCBI, 2022; USITC, 2022a).

Primary Industrial Consumers

In 2012, the primary use of citric acid is production of a foods and beverages (65%), household detergents and cleaners (23%), pharmaceuticals (5%), cosmetics (2%), and industrial and other uses (5%) (USITC, 2015).

Manufacturing, Transport, & Storage

Manufacturing Process

The primary method for the commercial manufacture of citric acid is the two-step process of fermentation followed by recovery and refinement.

Commercial fermentation requires a substrate and a mold or yeast. Corn is the most common substrate used in the United States. Through the metabolic reactions, the substrate is turned to glucose and fermented into crude citric acid.

Subsequent recovery and refinement of the citric acid is performed by one of three common methods: the lime/sulfuric acid method, the solvent extraction method, or the ion exchange method. It is unclear which method is most common to domestic production. All three methods proceed with a preciptation step, followed by recovery of a citric acid slurry which is then evaporated, crystalized, and dried (USITC, 2017).

Product Transport

Citric acid, available as a solution or in granular form, is widely transported in container and bulk by truck, rail, barge, and ship.

Storage and Shelf Life

Citric acid should be stored in a tightly closed container and kept in cool, dry conditions. When stored properly, citric acid (anhydrous and monohydrate) can have a shelf life of in excess of 24 months (Cargill, 2010; Puritan Products, 2017).

Domestic Production & Consumption

Domestic Production

Production data was collected from the 2016 EPA Toxic Substances Control Act (TSCA) Chemical Data Reporting (CDR) for the year 2015[1], while trade data was collected from the U.S. International Trade Commission (USITC) Dataweb, as characterized in Table 1. Both production and trade data are specific to citric acid.

Table 1. Citric Acid Production and Trade Data Sources

Production and Trade Data			
Category	**Data Source**	**Identifier**	**Description**
Domestic Production	2016 TSCA Chemical Data Reporting	CAS No.: 77-92-9	Citric Acid
Imports and Exports	U.S. International Trade Commission	HS Code: 2918.14	Citric Acid

Total U.S. domestic manufacturing of citric acid reported under the CDR was approximately 32 million kilograms (M kg) in 2015; however, several leading manufacturers claimed confidential business information and did not report production volumes to EPA (EPA, 2016). The number of domestic manufacturing locations shown in Figure 1 represents operating facilities as of 2015. Supply of NSF/ANSI Standard 60 certified citric acid for use in drinking water treatment is widely available (NSF International, 2021). For a more current listing of manufacturing locations and supplier locations, visit the U.S. Environmental Protection Agency's (EPA's) Chemical Locator Tool (EPA, 2022a).

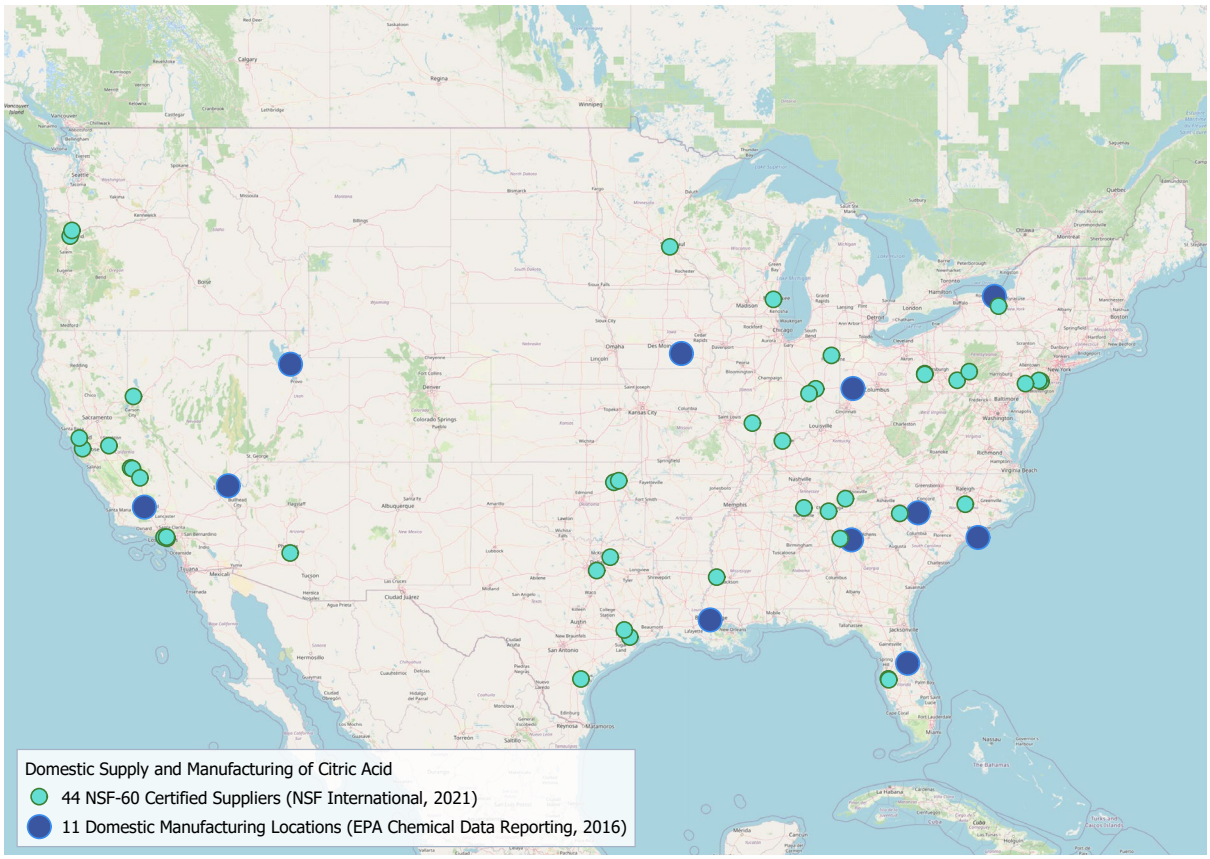


Figure 1. Domestic Supply and Manufacturing of Citric Acid

[1] Although 2019 CDR data is available, reporting is less complete when compared to 2015 data due to an increase in the number of companies claiming confidential business information (CBI). In both instances, CBI may account for a significant volume of citric acid produced that is not reflected in CDR reporting.

Domestic Consumption

U.S. consumption of citric acid in 2015 is estimated at 96 M kg. This includes production of 32 M kg, import of 75 M kg, minus export of 12 M kg (EPA, 2016; USITC, 2022a), as shown in Figure 2.

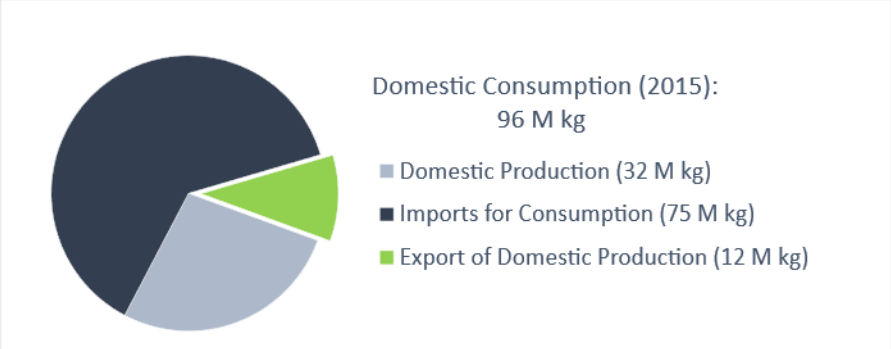


Figure 2. Domestic Production and Consumption of Citric Acid in 2019

Trade & Tariffs

Worldwide Trade

Worldwide import and export data for citric acid are reported through the World Bank's World Integrated Trade Solutions (WITS) software, as a category specific to citric acid. In 2021, the U.S. ranked tenth worldwide in total exports and second in total imports. In 2021, China ranked first worldwide in total exports while Germany ranked first in total imports (WITS, 2022), as shown in Table 2.

Table 2. WITS Worldwide Export and Import of Citric Acid in 2021

2021 Worldwide Trade Citric Acid (HS Code 2918.14)			
Top 5 Worldwide Exporters		Top 5 Worldwide Importers	
China	1,067 M kg	Germany	147 M kg
Belgium	114 M kg	**United States**	**113 M kg**
Thailand	106 M kg	India	102 M kg
Germany	34 M kg	Mexico	77 M kg
Netherlands	33 M kg	Poland	59 M kg

Domestic Imports and Exports

Domestic import and export data are reported by USITC in categories specific to citric acid. Figure 3 summarizes imports for consumption[2] and domestic exports[3] of citric acid between 2015 and 2020. During this period, the overall quantity of exports and imports remained relatively steady, with imports for consumption consistently exceeding domestic exports. Over this five-year period, Canada was the primary recipients of domestic exports while Thailand was the primary source of imports for consumption (USITC, 2022a).

[2] Imports for consumption are a subset of general imports, representing the total amount cleared through customs and entering consumption channels, not anticipated to be reshipped to foreign points, but may include some reexports.

[3] Domestic exports are a subset of total exports, representing export of domestic merchandise which are produced or manufactured in the U.S. and commodities of foreign origin which have been changed in the U.S.

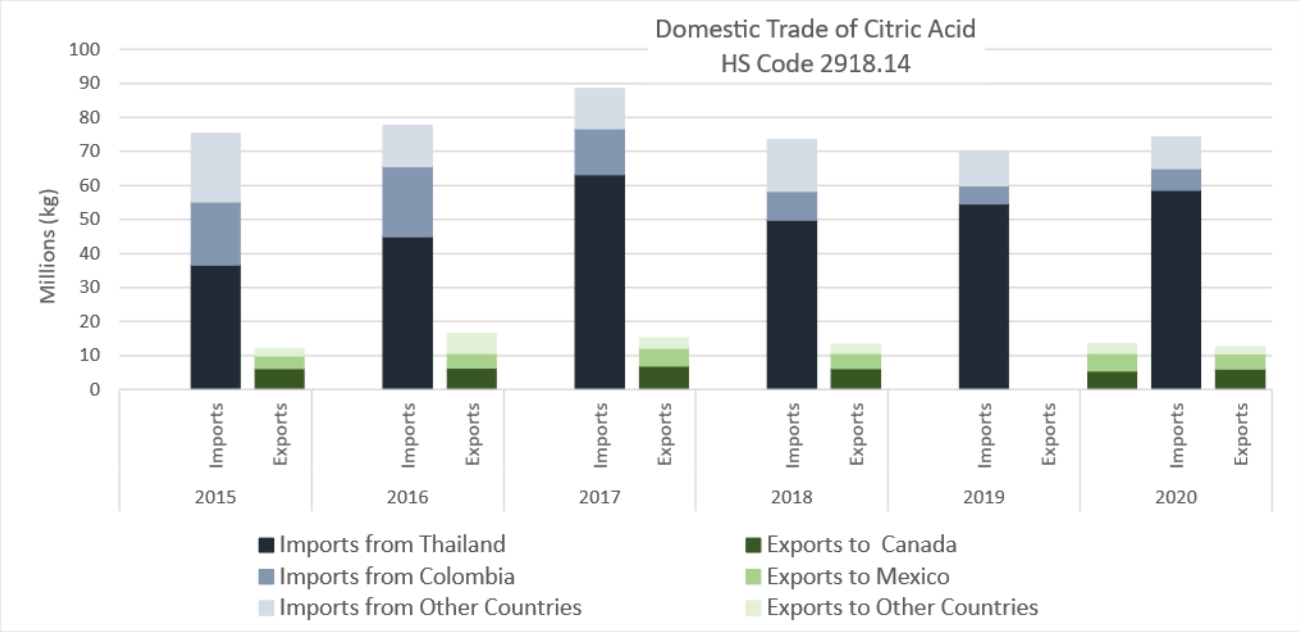


Figure 3. USITC Domestic Import and Export of Citric Acid between 2015 and 2020

Tariffs

There is a 6% general duty, and a 25% additional duty on imports from China (USITC, 2022b), as summarized in Table 3.

Table 3. Domestic Tariff Schedule for Citric Acid in 2021

HS Code	General Duty	Additional Duty – China (Section 301 Tariff List)	Special Duty
2918.14	6%	25%	Free (A, AU, BH, CL, CO, D, E, IL, JO, KR, MA, OM, P, PA, PE, S, SG)[4]

Market History & Risk Evaluation

History of Shortages

Domestic manufacturing has decreased over the past 20 years, and domestic demand is increasingly met through imports. In 2021, supply of citric acid became tight, due to reliance on imports to meet domestic demand and logistical and feedstock challenges of imported citric acid. Due to reliance on imports, periodic increases in price for citric acid have occurred, however there are no notable citric acid domestic supply chain disruptions impacting the water sector between 2000 and 2022.

Risk Evaluation

The complete risk assessment methodology is described in *Understanding Water Treatment Chemical Supply Chains and the Risk of Disruptions* (EPA, 2022b). The risk rating is calculated as the product of the following three risk parameters:

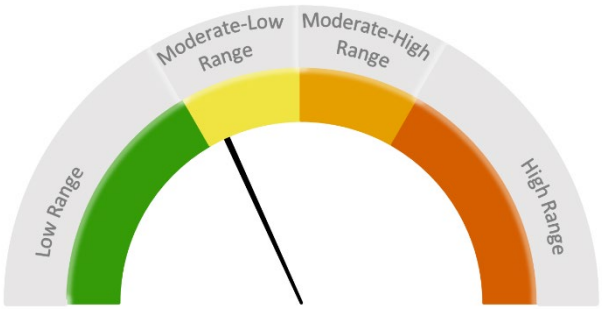
[4] Symbols used to designate the various preference programs and trade agreements. A full list of special trade agreements and associated acronyms can be found at https://help.cbp.gov/s/article/Article-310?language=en_US and the General Notes Section of the Harmonized Tariff Schedule https://hts.usitc.gov/current

Risk = Criticality x Likelihood x Vulnerability	
Criticality	Measure of the importance of a chemical to the water sector
Likelihood	Measure of the probability that the chemical will experience a supply disruption in the future, which is estimated based on past occurrence of supply disruptions
Vulnerability	Measure of the market dynamics that make a chemical market more or less resilient to supply disruptions

The individual parameter rating is based on evaluation of one or more attributes of the chemical or its supply chain. The ratings and drivers for these three risk parameters are shown below in Table 4.

Table 4. Supply Chain Risk Evaluation for Citric Acid

Risk Parameter Ratings and Drivers		
Criticality: High	**Likelihood: Moderate-Low**	**Vulnerability: Moderate-Low**
Citric acid is widely used for membrane cleaning.	The water sector has experienced significant price increases, but has not experienced citric acid supply chain disruptions between 2000 and 2022.	Domestic manufacturing is limited and meeting domestic demand depends on imports.
Risk Rating: Moderate-Low		



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