CCM Data & Business Intelligence

Production and Producer of Sodium Gluconate and Glucono-delta-lactone in China

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Executive summary

Sodium gluconate (SG), the sodium salt of gluconic acid, is used in concrete additive, water quality steadying agent, food and electroplating detergent industries in China. Glucono-delta-lactone (GDL) is a harmless food additive to the human body. In 2023, SG output and consumption decreased in China, while GDL output and consumption increased.

- Sodium gluconate

China's output of SG increased by 1.9% year on year in 2020, but then it decreased in 2021–2023 due to continued weak domestic demand. In 2023, national output dropped to 652,800 tonnes, down 1.7% year on year, and the top five domestic SG producers (by output) contributed to 90.8% of the total output. As of Dec. 2023, there were five SG manufacturers with capacity exceeding 100,000 t/a in China.

In 2023, affected by weak domestic demand, despite the weakening of USD against CNY, the annual average price of sodium gluconate fell to USD582/t.

As to SG production technology, the enzyme method has become a mainstream technology thanks to no fungal residue and less energy consumption, and the bio-fermentation method still plays an important role in the industry.

- Glucono-delta-lactone

As of Dec. 2023, there were eight active GDL producers in China. The top three producers (with two producers tied for the third spot by capacity) accounted for 66.2% of the total capacity. Thanks to profitable sales and growing market demand, the domestic output of GDL grew at a CAGR of 3.7% from 2019 to 2023, reaching 36,800 tonnes in 2023.

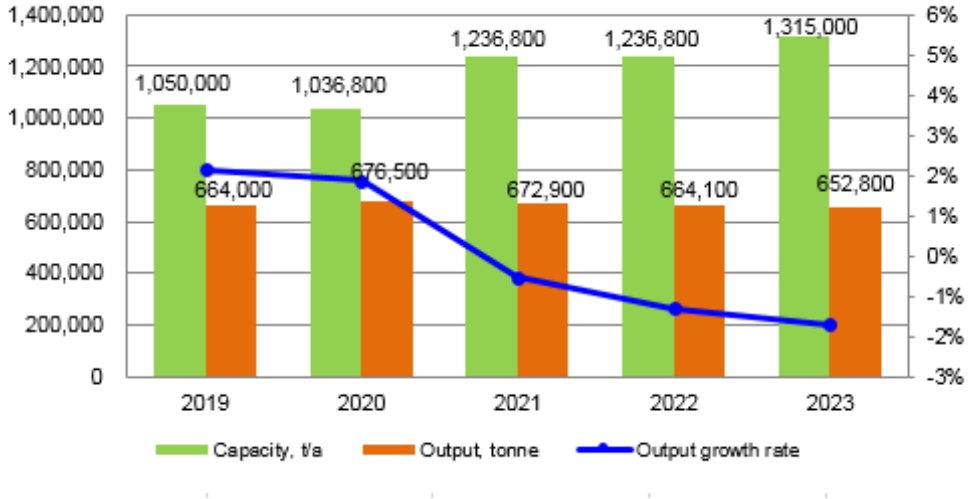
In 2023, the raw material price remained at a relatively low level throughout the year, the annual average ex-works price of GDL dropped to USD1,322/t.

There are four methods for GDL production, namely fermentation method, catalytic oxidation method, glucose oxidase method and electrolytic oxidation method, with glucose or starch as the starting material.

1 Production of sodium gluconate in China, 2023

1.1 Production

Figure 1.1-1 Capacity and output of sodium gluconate in China, 2019–2023



Source: CCM

In 2012–2015, the rapid growth of sodium gluconate capacity and lack of downstream demand led to the overcapacity of sodium gluconate in China. Starting in 2016, some sodium gluconate producers have exited the market due to decreasing profit margins and stricter environmental regulations. By 2018, the capacity of sodium gluconate in China dropped to 1,040,000 t/a.

In 2019, Shandong Fuyang Biotechnology Co., Ltd. (Shandong Fuyang)'s expansion project was completed, while Zhucheng Xingmao Corn Developing Co., Ltd. (Zhucheng Xingmao) reduced its capacity through technological transformation, bringing the national capacity to 1,050,000 t/a.

In 2021, the national capacity of sodium gluconate rose to 1,236,800 t/a as Yuxing Biotechnology (Group) Co., Ltd. (Yuxing Biotechnology) entered the market with its 200,000 t/a sodium gluconate production lines put into operation.

In 2023, Shandong Fuyang's 100,000 t/a sodium gluconate production line was built, raising the national capacity to 1,315,000 t/a.

In 2019–2020, the output of sodium gluconate in China increased steadily, maintaining a growth rate of about 2%. However, due to weak domestic demand, the output began to decline in 2021, and dropped further to 664,100 tonnes in 2022 and 652,800 tonnes in 2023, down 1.3% and 1.7% year on year, respectively.

1.2 Major producers

From 2014 to 2020, there had been an overall increase in the concentration of SG production in China. For one thing, the government had paid more attention to environmental protection and some SG producers had been eliminated from the market because of environmental and economic factors. For another thing, the development of China's construction industry and the

profits of SG business had encouraged the producers to enlarge their capacity, with some big players seeking to gain more market share.

Since 2021, nevertheless, the downturn in China's construction industry has affected the domestic demand for sodium gluconate. Some producers have reduced or even suspended SG production to maintain overall profitability, but some others remained confident in the market and have expanded production. The industry concentration decreased in 2021 but then picked up again in 2022 and 2023.

As of Dec. 2023, there were five manufacturers with sodium gluconate (SG) capacity exceeding 100,000 t/a, namely Shandong Fuyang, Yuxing Biotechnology, Jining Guangji Pharma, Zhucheng Xingmao and Xiwang Sugar. In 2023, the top five SG producers (by output) produced more than 590,000 tonnes, with their combined share of the total at about 90.8%.

In 2023, China's SG production was mainly concentrated in Shandong Province and Hebei Province, with the combined output accounting for more than 80% of the national total.

Table 1.2-1 Major sodium gluconate producers in China, as of March 2024

No.	Producer	Abbreviation	Location	Produce glucono-delta-lactone, Yes/No	Status, as of March 2024
1	Shandong Fuyang Biotechnology Co., Ltd.	Shandong Fuyang	Shandong	Yes	Active
2	Yuxing Biotechnology (Group) Co., Ltd.	Yuxing Biotechnology	Hebei	No	Active
3	Guangji Pharmaceutical (Jining) Co., Ltd.*1	Jining Guangji Pharma	Shandong	Yes	Active
4	Zhucheng Xingmao Corn Developing Co., Ltd.	Zhucheng Xingmao	Heilongjiang, Inner Mongolia	No	Idle
5	Shandong Xiwang Sugar Co., Ltd.	Xiwang Sugar	Shandong	No	Idle
6	Zhucheng Yuanfa Biotechnology Co., Ltd.*2	Zhucheng Yuanfa	Shandong	No	Active
7	Weifang Jianbao Biotechnology Co., Ltd.	Weifang Jianbao	Shandong	No	Active
8	Qingdao Kehai Biochemistry Co., Ltd.	Qingdao Kehai	Shandong	No	Active
9	Shandong Kaixiang Biochemical Co., Ltd.	Shandong Kaixiang	Shandong	Yes	Active
10	Zhejiang Wulong New Materials Co., Ltd.	Zhejiang Wulong	Zhejiang	No	Active
11	Zhejiang Tianyi Food Additives Co., Ltd.	Zhejiang Tianyi	Zhejiang	Yes	Active
12	Deqing Yuansu Gaoke Biotechnology Co., Ltd.	Deqing Yuansu	Zhejiang	No	Active
13	Xinxiang Zhongxin Chemicals Co., Ltd.	Xinxiang Zhongxin	Henan	No	Suspended

Note:
1. Guangji Pharmaceutical (Jining) Co., Ltd., formerly known as Shandong Baisheng Biotechnology Co., Ltd., was established in April 2023 and was commissioning production equipment as of March 2024.
2. Zhucheng Yuanfa Biotechnology Co., Ltd., merged with Zhucheng Shuguang Biotechnology Co., Ltd. in July 2023, is a subsidiary of Dongxiao Biotechnology Co., Ltd.
Source: CCM

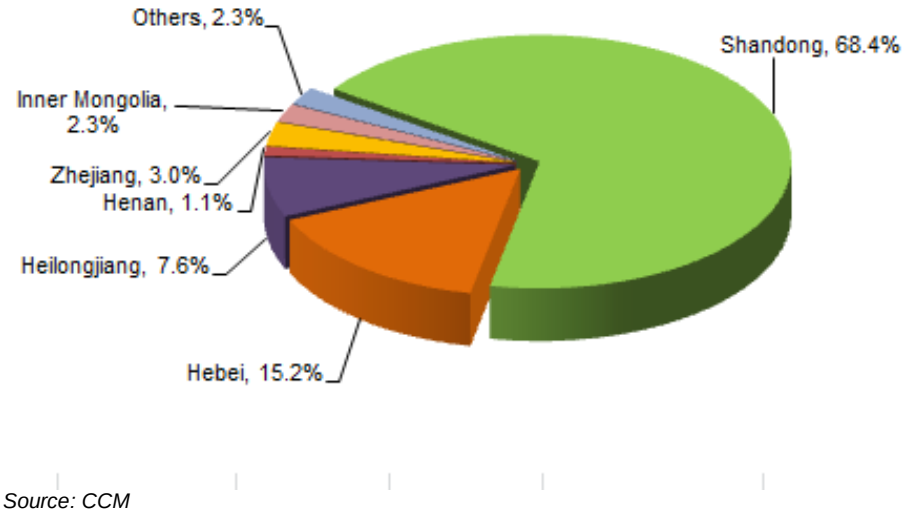
Table 1.2-2 Capacity and output of major sodium gluconate producers in China, 2020–2023

No.	Producer	Capacity, t/a				Output, tonne							
						2023		2022		2021		2020	
		2023	2022	2021	2020	Solid	Liquid	Solid	Liquid	Solid	Liquid	Solid	Liquid
1	Shandong Fuyang	350,000	250,000	250,000	250,000	236,000	0	210,000	0	188,000	0	215,000	0
2	Yuxing Biotechnology	200,000	200,000	200,000	/	132,000	0	110,000	0	98,000	0	/	/
3	Jining Guangji Pharma	150,000	150,000	150,000	150,000	0	0	0	0	32,000	2,000	105,000	6,000
4	Zhucheng Xingmao	130,000	130,000	130,000	130,000	98,000	3,200	116,000	6,000	120,000	6,000	120,000	6,500
5	Xiwang Sugar	120,000	120,000	120,000	120,000	0	0	69,000	0	91,000	0	115,000	0
6	Zhucheng Yuanfa	100,000	100,000	100,000	100,000	70,300	0	57,200	0	49,500	0	44,200	0
7	Weifang Jianbao	100,000	100,000	100,000	100,000	56,700	0	47,800	0	41,500	0	35,000	0
8	Qingdao Kehai	50,000	50,000	50,000	50,000	18,600	0	15,000	0	12,000	0	0	0
9	Shandong Kaixiang	30,000	30,000	30,000	30,000	26,600	2,500	25,800	2,000	26,500	3,000	27,000	2,000
10	Zhejiang Wulong	30,000	30,000	30,000	30,000	3,400	0	2,500	0	3,000	0	2,500	0

11	Zhejiang Tianyi	6,000	6,000	6,000	6,000	5,000	0	4,500	0	4,900	0	5,000	0
12	Deqing Yuansu	4,000	4,000	4,000	4,000	2,200	350	2,300	400	2,500	400	3,000	400
13	Xinxiang Zhongxin	15,000	15,000	15,000	15,000	0	0	0	0	0	0	800	100
Others		30,000	51,800	51,800	51,800	4,000	3,000	4,000	3,000	4,000	3,000	4,000	3,000
Total		**1,315,000**	**1,236,800**	**1,236,800**	**1,036,800**	**652,800**	**9,050**	**664,100**	**11,400**	**672,900**	**14,400**	**676,500**	**18,000**

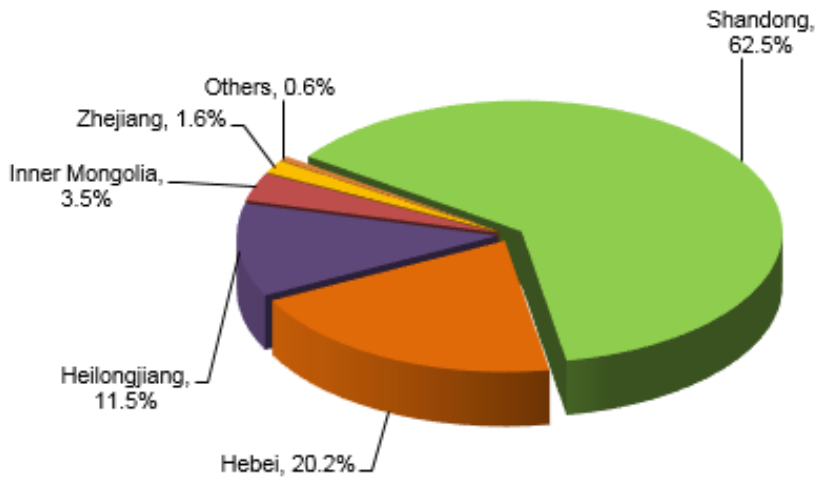
Source: CCM

Figure 1.2-1 Capacity distribution of sodium gluconate in China, 2023



Source: CCM

Figure 1.2-2 Output distribution of sodium gluconate in China, 2023



Source: CCM

Since 2020, Guangdong Redwall New Materials Co., Ltd. has stopped producing liquid SG due to its business adjustment.

Yuxing Biotechnology completed the construction of 200,000 t/a SG production lines in Xingtai City, Hebei Province, and put them into production in 2021.

Shandong Baisheng Biotechnology Co., Ltd. (Baisheng Biotechnology) stopped its business in 2022 due to a shortage of working capital. But in 2023, it was acquired by Hubei Guangji Pharmaceutical Co., Ltd. (Guangji Pharma, stock code: 000952.SZ), and will be operated again in the future by Jining Guangji Pharma, a subsidiary of Guangji Pharma.

Shandong Fuyang's 100,000 t/a sodium gluconate complex production line project, which was built by its subsidiary Dezhou Heyang Biotechnology Co., Ltd., was completed in 2023, increasing its total capacity to 350,000 t/a.

Zhucheng Xingmao reduced its SG production in 2023 because of the decreased profit margins of the product. In March 2023, its two subsidiaries Tongliao Zhongyuan Biological Development Co., Ltd. and Heilongjiang Longfeng Corn Development Co., Ltd. released relevant technical transformation plans, upon completion of which the total SG capacity of Zhucheng Xingmao will be reduced from 130,000 t/a to 60,000 t/a.

Due to corporate development decisions, Xiwang Sugar stopped its SG business in 2023 and shifted its focus to other corn deep-processed products.

There are two potential SG producers in China, namely Heilongjiang Zhonglang Biotechnology Co., Ltd. (Heilongjiang Zhonglang) and Anhui BBCA Biochemical Co., Ltd. (Anhui BBCA).
- Heilongjiang Zhonglang's corn deep-processing project (300,000 t/a of corn starch, 100,000 t/a of SG, and 50,000 t/a of itaconic acid) was still under construction as of Dec. 2023.
- The environmental impact (EI) report of Anhui BBCA's 10,000 t/a SG and 20,000 t/a L-alanine technical transformation project was approved on Feb. 15, 2023. And previously on April 29, 2022, the company publicised the EI report of a 50,000 t/a SG project, yet there has been no update on this project.

Link of expansion project:
https://sthjj.bengbu.gov.cn/zfxxgk/public/22131/50418393.html
https://sthjj.bengbu.gov.cn/hbyw/hpsp/hjyxpj/xmslqk/9197067.html
https://www.guzhen.gov.cn/zfxxgk/public/25821/49793343.html

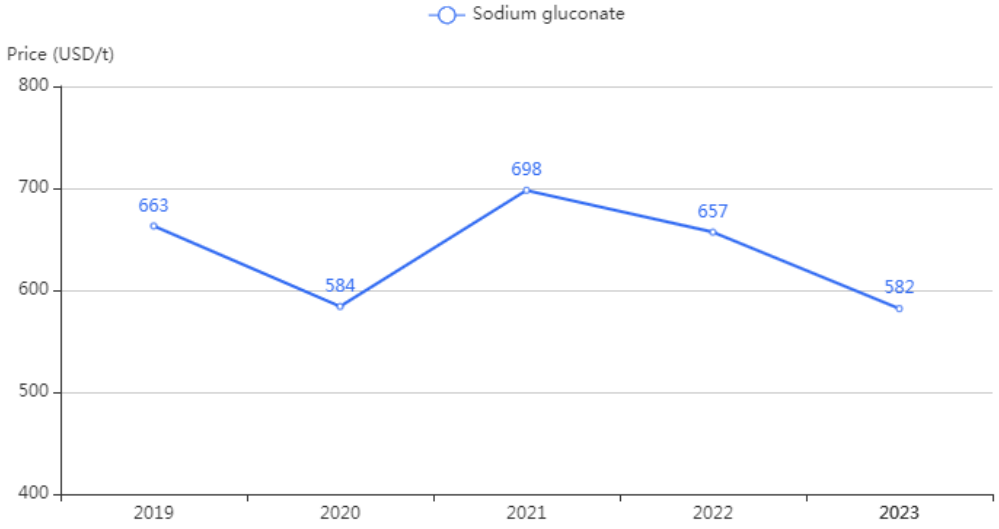
1.3 Price

Table 1.3-1 Ex-works price of sodium gluconate by major producers in China, March 2024

No.	Producer	Food grade		Industrial grade	
		RMB/t	USD/t	RMB/t	USD/t
1	Shandong Fuyang	4,230	595	4,230	595
2	Zhucheng Yuanfa	4,180	588	/	/
3	Qingdao Kehai	4,700	661	4,600	647
4	Shandong Kaixiang	5,300	746	4,400	619
5	Zhejiang Wulong	/	/	5,100	718
6	Zhejiang Tianyi	5,000	704	/	/
7	Deqing Yuansu	5,500	774	/	/

Source: CCM

Figure 1.3-1 Annual average ex-works price of sodium gluconate in China, 2019–2023



Source: CCM

In 2019, as the price of raw material corn came down, the annual average ex-works price dropped to USD663/t, down 4.2% year on year. The annual average price plunged to USD584/t in 2020, due to factors like the outbreak of COVID-19, sufficient supply of sodium gluconate, stronger USD against CNY, etc.

Throughout the year 2021, the monthly ex-works price of sodium gluconate stayed above USD660/t as USD continued to weaken against CNY. The price surpassed USD700/t in Q4 and peaked at USD779/t in Nov. as the price of corn starch rose.

With the decline of corn starch price and the strengthening of USD against CNY, the annual average ex-works price of sodium gluconate retreated to USD657/t in 2022.

In 2023, due to continued weak domestic demand, despite the weakening of USD against CNY, the annual average price of sodium gluconate fell back to USD582/t, close to the price level in 2020.

1.4 Production technology

Currently, there are mainly three sodium gluconate production methods in China, namely catalytic oxidation method, bio-fermentation and enzyme method, in which bio-fermentation method is the most commonly adopted method in industrial production of sodium gluconate.

Bio-fermentation method is mainly adopted by sodium gluconate producers which are located in the surrounding areas of corn-planting regions such as Shandong Province.

The catalytic oxidation method developed rapidly in the 1980s and 1990s. However, due to the use of costly metal catalysts, the production cost is subject to the number and efficiency of metal catalyst cycles. Besides, due to the presence of excess heavy metals, products thus produced are not allowed to be used as food additives in food production. Therefore, the development of the catalytic oxidation method is limited. At present, this method is mainly adopted by small and medium-sized enterprises to produce industrial-grade products for the concrete industry.

The enzyme method has developed rapidly in recent years and is receiving increasing attention from the sodium gluconate industry. Weifang Jianbao Biotechnology Co., Ltd. and Shandong Kaixiang Biochemical Co., Ltd. started to adopt the enzyme method in sodium gluconate production in 2016 and 2018, respectively. Shandong Fuyang completed the technological transformation project in 2021, changing its production method of sodium gluconate from bio-fermentation to the enzyme method. No fungal residue is generated during the production process by the enzyme method, which overcomes the disadvantage of impure products produced by the bio-fermentation method. Besides, this method consumes less energy than the bio-fermentation method.

Moreover, Dongxiao Biotechnology Co., Ltd., applied for a patent for an energy-efficient and environment-friendly enzyme method of sodium gluconate production in 2016. Different from the traditional enzyme method, this new approach uses starch slurry as the starting material and improves SG quality by saccharification. According to the company, the method is safer, and easier to extract and refine products. In addition, through comprehensively utilizing the heat released during the process, the method can bring down energy consumption and carbon emissions.

Therefore, it is foreseeable that the enzyme method will be more widely used in SG production.

Manufacturing principle of various sodium gluconate production methods

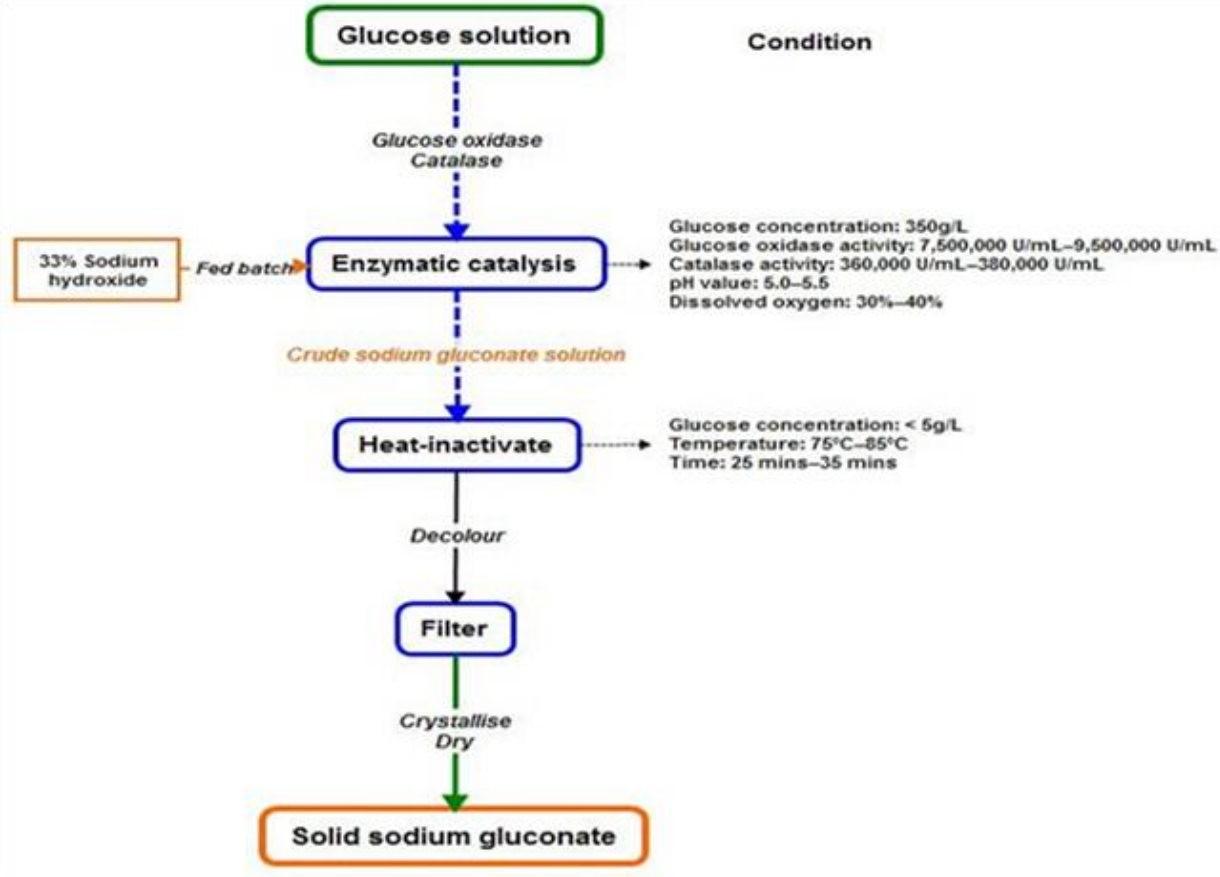
- Catalytic oxidation method: Oxidate glucose solution into gluconic acid using a metal catalyst, and then add sodium hydroxide to neutralize gluconic acid into sodium gluconate.
- Bio-fermentation method: Using *Aspergillus niger* to ferment glucose solution into gluconic acid, add sodium hydroxide to neutralize gluconic acid into sodium gluconate.
- Enzyme method: Ferment glucose solution using glucose oxidase and catalase, in which the glucose oxidase will convert glucose into gluconic acid and hydrogen peroxide, while catalase will decompose hydrogen peroxide into oxygen and water. Add sodium hydroxide to neutralize gluconic acid into sodium gluconate.

Table 1.4-1 Comparison of various sodium gluconate production methods in China

Item	Catalytic oxidation method	Bio-fermentation method	Enzyme method
Raw materials	Glucose solution, metal catalyst, sodium hydroxide	Glucose solution, *Aspergillus niger*, sodium hydroxide	Glucose solution, glucose oxidase, catalase, sodium hydroxide
Production route	Simple	Complicated	Simple
Production cost	High	Low	Relatively high
Product purity	Relatively low	Low	High

Source: CCM

Figure 1.4-1 General production routes of enzyme method for sodium gluconate production



Source: CCM

Table 1.4-2 Production method of sodium gluconate by producer in China, 2023

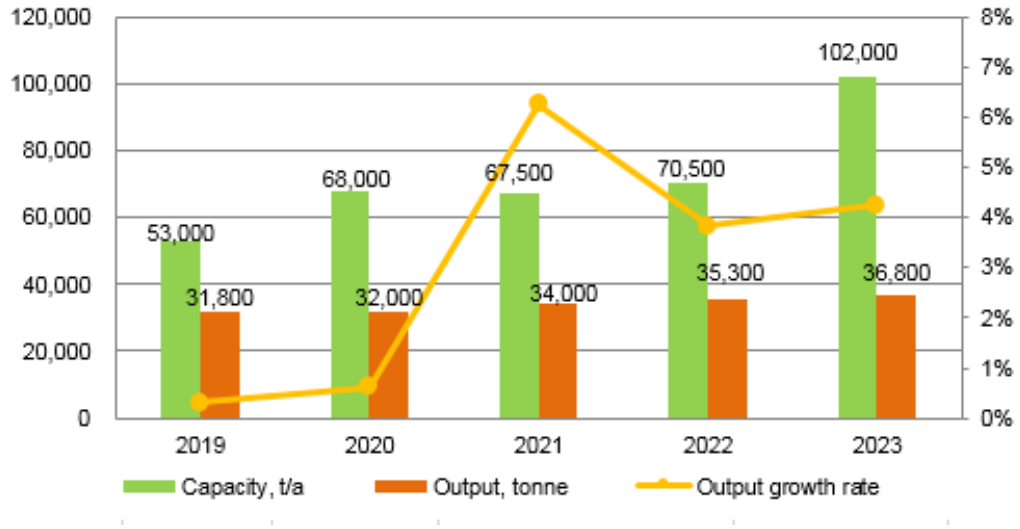
Production method	Producer
Bio-fermentation method	Zhucheng Xingmao, Zhucheng Yuanfa, Jining Guangji Pharma, Xiwang Sugar, Xinxiang Zhongxin, Zhejiang Tianyi, Qingdao Kehai
Enzyme method	Shandong Fuyang, Weifang Jianbao, Shandong Kaixiang, Yuxing Biotechnology
Catalytic oxidation method	Zhejiang Wulong, Deqing Yuansu

Source: CCM

2 Supply of glucono-delta-lactone in China, 2023

2.1 Production

Figure 2.1-1 Capacity and output of GDL in China, 2019–2023



Source: CCM

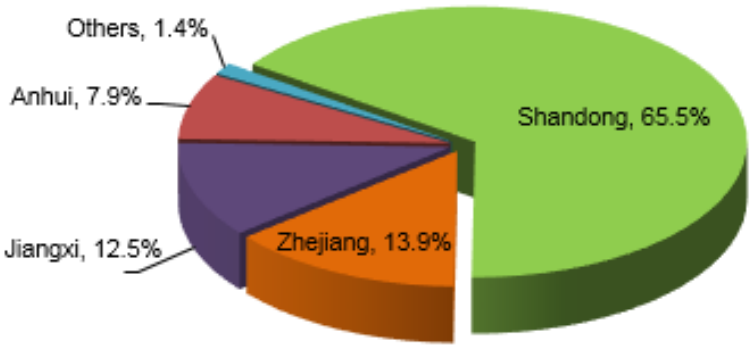
In 2020, Shandong Xinhong Pharmaceutical Co., Ltd. (Shandong Xinhong) joined the market and thus brought China's total GDL capacity to 68,000 t/a.

With the increasingly stricter environmental production inspections, Yibin GraceBIO Biological Technology Co., Ltd. and Zhangshu Guanyi Food Additive Co., Ltd. exited the market in 2021–2022. But at the same time, a new player Shandong Liujiangyuan Food Technology Co., Ltd. entered the market, and Shandong Kaixiang enlarged its GDL capacity, with the domestic capacity reaching 70,500 t/a in 2022.

In 2023, Shandong Zhongxing Food Technology Co., Ltd. (Shandong Zhongxing) finished its new project, and Dezhou Huiyang Biotechnology Co., Ltd. (Dezhou Huiyang) completed the expansion project, raising the total domestic capacity to 102,000 t/a.

Thanks to profitable sales and growing market demand, the domestic output of GDL grew at a CAGR of 3.7% from 2019 to 2023, and the output reached 36,800 tonnes in 2023. Due to the rapid expansion of domestic GDL capacity, the average annual operating rate has shown a downward trend in the past five years, and the operating rate dropped below 40% in 2023. In this case, future demand growth matters.

Figure 2.1-2 Output distribution of GDL in China, 2023



Source: CCM

Shandong Province is a major producing region for GDL and its raw materials—glucose and sodium gluconate. In 2023, Shandong's GDL output accounted for 65.5% of the national total.

In 2023, there were eight active GDL producers in China. The top three producers (with two producers tied for the third spot by capacity) accounted for 66.2% of the total capacity. In 2020–2023, due to the entry of new enterprises Shandong Xinhong, Shandong Liujiangyuan and Shandong Zhongxing, the market competition became increasingly intense. State-owned companies rarely enter the GDL market because GDL is not an important product affecting people's livelihood, so most Chinese GDL enterprises are private. So far, the Chinese government has no intention to restrict the business.

Table 2.1-1 Basic information about GDL producers in China, 2023

No.	Producer	Abbreviation	Status 2023	Location	Launch time
1	Shandong Kaixiang Biochemical Co., Ltd.	Shandong Kaixiang	Active	Shandong	2006
2	Shandong Xinhong Pharmaceutical Co., Ltd.	Shandong Xinhong	Active	Shandong	2020
3	Zhejiang Tianyi Food Additives Co., Ltd.	Zhejiang Tianyi	Active	Zhejiang	2011
4	Jiangxi New Huanghai Food Co., Ltd.	Jiangxi New Huanghai	Active	Jiangxi	2003
5	Dezhou Huiyang Biotechnology Co., Ltd.	Dezhou Huiyang	Active	Shandong	2014
6	Anhui Xingzhou Medicine & Food Co., Ltd.	Anhui Xingzhou	Active	Anhui	2003
7	Shandong Liujiangyuan Food Technology Co., Ltd.	Shandong Liujiangyuan	Active	Shandong	2021
8	Shandong Zhongxing Food Technology Co., Ltd.	Shandong Zhongxing	Active	Shandong	2023
9	Guangji Pharmaceutical (Jining) Co., Ltd.*1	Jining Guangji Pharma	Idle	Shandong	2014

Note:
1. Guangji Pharmaceutical (Jining) Co., Ltd. was formerly known as Shandong Hongsheng Biotechnology Co., Ltd.
Source: CCM

Table 2.1-2 Capacity and output of GDL producers in China, 2020–2023

No.	Producer	Capacity, t/a				Output, tonne			
		2023	2022	2021	2020	2023	2022	2021	2020
1	Shandong Kaixiang	15,000	15,000	12,000	12,000	9,700	9,600	7,000	6,500
2	Shandong Xinhong	15,000	15,000	15,000	15,000	6,800	7,200	5,800	2,000
3	Zhejiang Tianyi	6,000	6,000	6,000	6,000	5,100	5,500	5,600	5,500
4	Jiangxi New Huanghai	5,000	5,000	5,000	5,000	4,200	4,400	4,500	4,500
5	Dezhou Huiyang	20,000	3,000	3,000	3,000	3,600	3,000	3,000	3,000
6	Anhui Xingzhou	5,000	5,000	5,000	5,000	2,900	3,200	1,500	0
7	Shandong Liujiangyuan	7,500	7,500	7,500	/	2,200	1,900	600	/
8	Shandong Zhongxing	17,500	/	/	/	1,800	/	/	/
9	Jining Guangji Pharma	10,000	10,000	10,000	10,000	0	0	5,500	8,000
Others		1,000	4,000	4,000	12,000	500	500	500	2,500
Total		**102,000**	**70,500**	**67,500**	**68,000**	**36,800**	**35,300**	**34,000**	**32,000**

Source: CCM

Anhui Xingzhou suspended GDL production in 2018–2020 due to environmental protection inspections and resumed production in 2021. In addition to selling its own GDL products, Anhui Xingzhou is also a GDL products agent.

Shandong Xinhong had 15,000 t/a GDL capacity added in Oct. 2020, upon completion of its 18,000 t/a gluconate project.

In 2021, Shandong Liujiangyuan put its 10,000 t/a gluconic acid and derivatives project (phase I) into operation, giving it the capacity to produce 7,500 t/a of GDL. The company sells GDL products through Anhui Xingzhou.

Shandong Kaixiang's GDL technical transformation project was completed in March 2022, increasing its GDL production scale to 15,000 t/a from 12,000 t/a. It has been China's largest GDL producer by output for the past three years.

Dezhou Huiyang completed its 20,000 t/a GDL expansion project in July 2023, becoming the largest producer by domestic capacity. At present, its GDL products are sold by itself and are no longer sold by Anhui Xingzhou.

Shandong Zhongxing's 20,000 t/a gluconate series food additives (including 17,500 t/a GDL) project was put into production in Q2 2023, becoming China's second-largest producer by capacity.

Shandong Hongsheng Biotechnology Co., Ltd. (Shandong Hongsheng), a subsidiary of Baisheng Biotechnology, stopped producing GDL in 2022–2023 due to financial woes. After Guangji Pharma's acquisition of Baisheng Biotechnology and its subsidiaries, Shandong Hongsheng will likely be taken over and operated again by Jining Guangji Pharma, a subsidiary of Guangji Pharma.

There are also three potential GDL producers in China: Yuxing Biotechnology, Angel Yeast (Yichang) Co., Ltd. (Yichang Angel) and Hebei Zhaorang New Materials Co., Ltd. (Hebei Zhaorang).

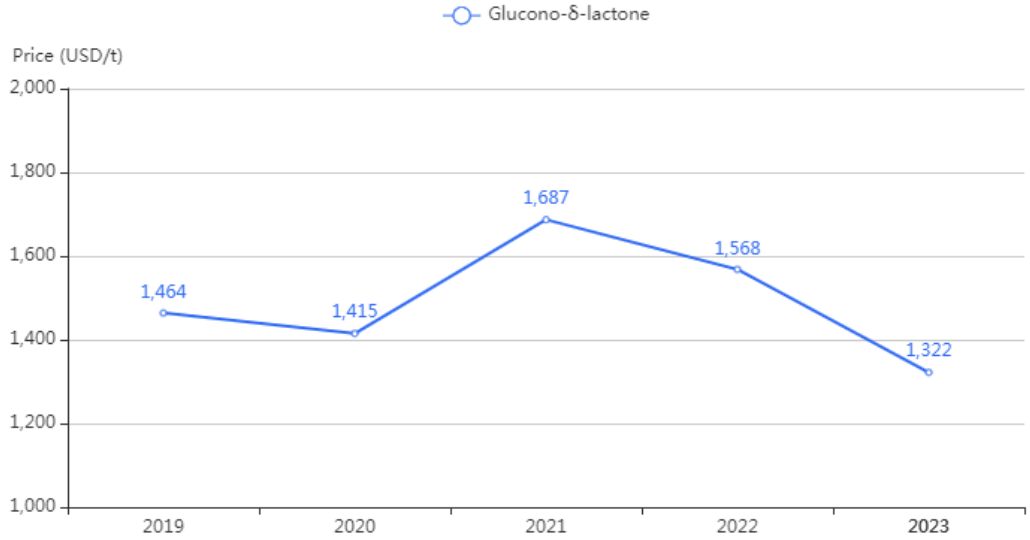
- Yuxing Biotechnology acquired the construction land use permit for the 10,000 t/a GDL project in Dec. 2020, but the project has not been completed as of March 2024.
Link of expansion project:
https://www.ningjin.gov.cn/xxgk/content/27007.html

- In Dec. 2021, Angel Yeast Co., Ltd. announced that its subsidiary Yichang Angel would undertake the construction of the 150,000 t/a hydrolyzed sugar deep processing project. According to the planning, some 35,000 tonnes of hydrolyzed sugar produced will be used for the production of GDL and in other deep processing projects. This large-scale project is planned in two phases: the construction of the hydrolyzed sugar workshop in Phase I and the construction of the GDL production line in Phase II. However, the company has not disclosed the design capacity for its GDL production line.
Link of expansion project:
http://www.cninfo.com.cn/new/disclosure/detail?plate=sse&orgId=gssh0600298&stockCode=600298&announcementId=1211947750&announcementTime=2021-12-18

- The EI report of Hebei Zhaorang's 12,000 t/a GDL and gluconate construction project was publicized in May 2023 before approval. After the completion of this project, Hebei Zhaorang's capacity of GDL will reach 10,000 t/a. This project could be completed as early as 2024.
Link of expansion project:
http://info.nangong.gov.cn/content/37350.html
http://info.nangong.gov.cn/content/37352.html

2.2 Price

Figure 2.2-1 Annual average ex-works price of GDL in China, 2019–2023



Source: CCM

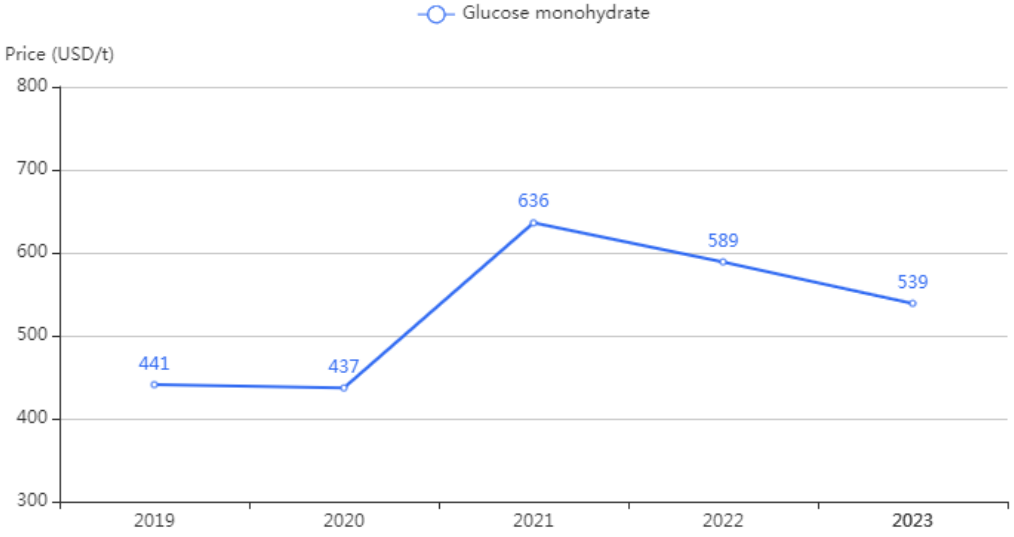
As people's health consciousness constantly enhanced, the demand for GDL, a harmless food additive to the human body, grew steadily in recent years. The growth of demand outpaced that of supply, so the year 2019 saw the price further increase by 2.9% year on year.

In 2020, the annual average ex-works price of GDL decreased a little by 3.4% year on year.

In 2021, as the raw material price rose, the annual ex-works price of GDL averaged USD1,687/t, rising 19.2% year on year. In 2022, it decreased by 7.1% year on year to USD1,568/t, along with declined prices of raw materials.

In 2023, as the raw material price remained at a relatively low level throughout the year, the annual average ex-works price of GDL dropped to USD1,322/t. Besides, with the decline of Anhui Xingzhou's sales share and its pricing power of GDL in the market, other manufacturers have reduced prices in order to gain more market share.

Figure 2.2-2 Average ex-works price of glucose monohydrate in China, 2019–2023



Source: CCM

Generally, the price of glucose fluctuates with the price of corn starch, as well as that of corn.

In 2019, the price of corn slipped by 3.0% year on year, primarily due to lower demand for corn feed caused by African swine fever. As a result, the annual average price of glucose monohydrate was reduced by 7.4% year on year. The price of glucose monohydrate continued to fall in H1 2020 influenced by the outbreak of COVID-19, but rose in H2 along with the rising price of corn.

In 2021, the price of glucose monohydrate was kept high throughout the year. The monthly price jumped to USD581/t in Jan. and shot further to USD681/t in Feb. before some small pullbacks were seen. In Q4, as the corn price rose, it again climbed to around USD655/t.

In March 2022, the price of glucose monohydrate came to a peak at USD682/t, but then began to decline, falling all the way to USD521/t in Oct. The price ended at USD552/t in Dec. 2022.

Corn prices showed a volatile decline in 2023, and the annual average ex-works price of glucose monohydrate fluctuated between USD519/t–USD563/t.

2.3 Production technology

2.3.1 Different pathways/methods

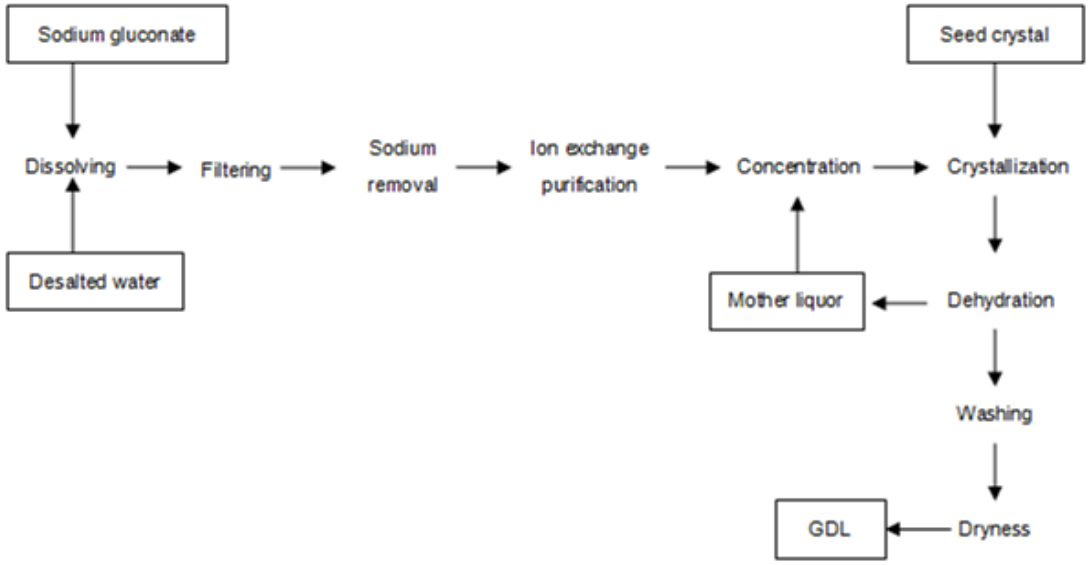
There are four methods for GDL production, namely fermentation method, catalytic oxidation method, glucose oxidase method and electrolytic oxidation method, with glucose or starch as the starting material.

The fermentation method has become the most important production technology in recent years in China, mainly attributed to its low manufacturing cost and sufficient raw material supply. And there are three paths to produce GDL through the fermentation method. One is getting the GDL directly through fermentation; the other two paths are transferring glucose liquid to sodium gluconate (SG) or to calcium gluconate (CG), and eventually turning it into GDL.

In the fermentation method, glucose or maltose is used as the starting material. In China, glucose is made into glucose solution first, then transferred to CG or SG after fermentation, and made into GDL finally.

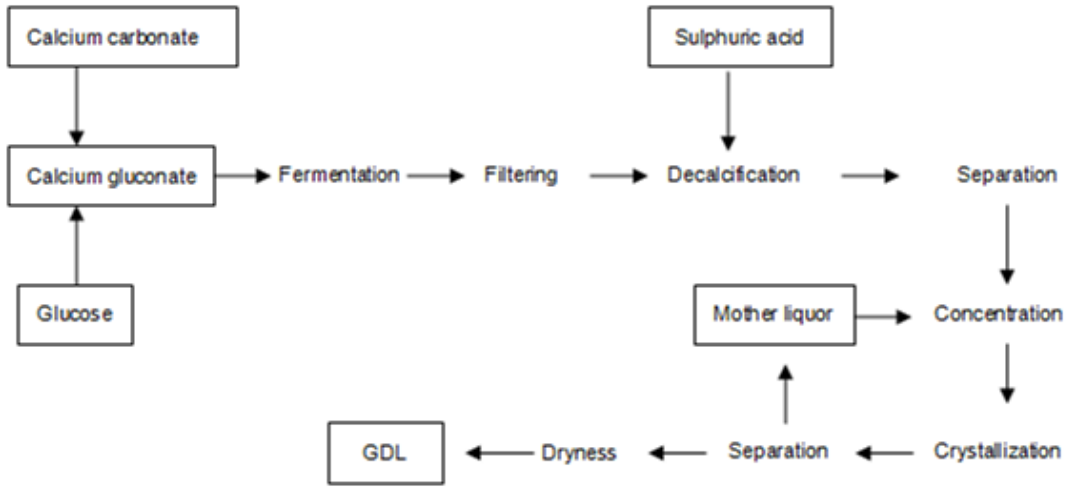
Shandong Xinhong adopts the glucose oxidase method, with glucose as a raw material. It adds oxidase and sodium hydroxide into glucose solution for oxidation treatment. After that, sodium ions are absorbed by resin to obtain gluconic acid solutions, and then GDL is extracted through crystallization.

Figure 2.3.1-1 Flowchart of sodium gluconate method in China



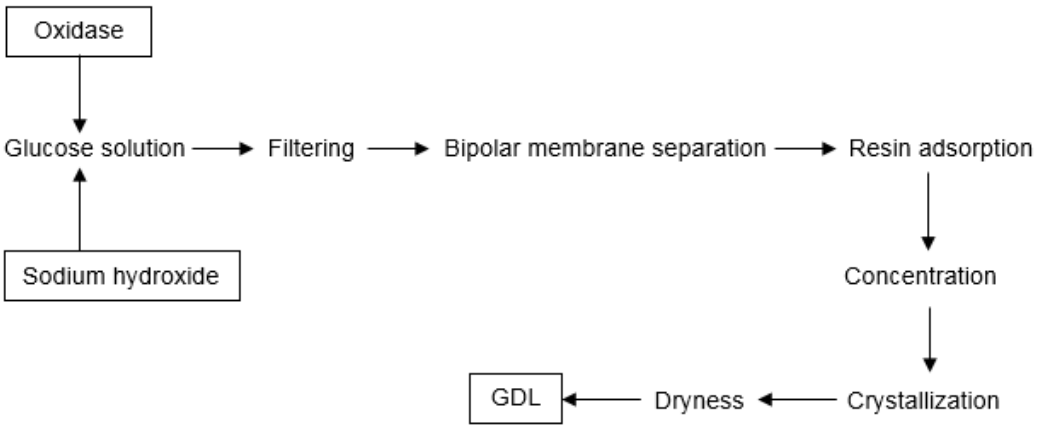
Source: CCM

Figure 2.3.1-2 Flowchart of calcium gluconate method in China



Source: CCM

Figure 2.3.1-3 Flowchart of Shandong Xinhong's GDL method



Source: CCM

Table 2.3.1-1 Production method of GDL by producer in China, 2023

No.	Producer	Technology	Raw material	Raw material source
1	Shandong Kaixiang	SG method	SG	Captive
2	Dezhou Huiyang	SG method	SG	Outsourcing
3	Shandong Liujiangyuan	SG method	SG	Outsourcing
4	Shandong Zhongxing	CG method	Calcium carbonate and glucose	Outsourcing
5	Shandong Xinhong	Glucose oxidase method	Glucose	Outsourcing
6	Zhejiang Tianyi	Fermentation method	Glucose	Outsourcing
7	Jiangxi New Huanghai	Fermentation method	Glucose	Outsourcing
8	Anhui Xingzhou	Fermentation method	Rice/Corn starch	Outsourcing

Source: CCM

2.3.2 Research status

There are only a small number of researchers, research institutes/companies involved in GDL production technology development in China, with 8 patents of GDL producing methods in total since 2009.

Three production methods are adopted for commercial use.
- Shandong Kaixiang adopts the method developed by Xiamen Starmem Scitechnology Co., Ltd. and the equipment made by Nanjing Gaojie Light Industrial Equipment Co., Ltd.
- Dezhou Huiyang used to apply the method of its parent company Shandong Fuyang to produce GDL, but it has switched to the SG method in the subsequent expansion.
- Jiangsu Huanyu Kangli Technology Co., Ltd. (Jiangsu Kangli) adopts its own designed methods and equipment to produce GDL (usually for its own use).

Three GDL production methods (under review/authorized patent) developed by Anhui Xingzhou have not been applied to actual production.

One preparation method developed by China Tobacco Hubei Industrial LLC is suitable for pilot-line production only. Another preparation method, developed by Qingdao Bright Moon Seaweed Group Co., Ltd., has also not been applied to large-scale production.

Table 2.3.2-1 Patents related to GDL production applied in China, as of March 2024

No.	Patent	Application No.	Applicant	Date of application
1	A production process of GDL	CN202110640969.5	Anhui Xingzhou	Dec. 2022
2	An environmentally friendly GDL processing method	CN202111581379.6	Anhui Xingzhou	March 2022
3	A production method and processing equipment of GDL	CN202111340530.7	Anhui Xingzhou	Nov. 2021
4	A production process and equipment for preparing GDL from sodium gluconate	CN202111232278.8	Jiangsu Kangli	Oct. 2021
5	A preparation method of GDL and its application in essence for tobacco	CN201711089899.9	China Tobacco Hubei Industrial LLC	Nov. 2017
6	A method of preparing trehalose and GDL at the same time	CN201610710587.4	Dezhou Huiyang	Aug. 2016
7	A method for co-producing GDL, mannose and mannitol	CN201310362729.9	Qingdao Bright Moon Seaweed Group Co., Ltd.	Jan. 2016
8	A production method of GDL	CN200910192646.3	Xiamen Starmem Technology Co., Ltd.	Sept. 2009

Source: China National Intellectual Property Administration

3 Forecast on sodium gluconate and GDL production in China

Domestic demand for SG will continue to be affected until the construction industry recovers, although the export demand is performing well. Still, some enterprises intend to build new SG projects, which are often seen as a move to expand their corn deep-processing chain.

If the new projects of Heilongjiang Zhonglang and Anhui BBCA go well, China's SG capacity will be over 1,355,000 t/a in 2024.

Table 3-1 Forecast on SG capacity in China to 2027

No.	Producer	Capacity, t/a							
		2020	2021	2022	2023	2024	2025	2026	2027
1	Shandong Fuyang	250,000	250,000	250,000	350,000	350,000	350,000	350,000	350,000
2	Zhucheng Xingmao	130,000	130,000	130,000	130,000	60,000	60,000	60,000	60,000
3	Jining Guangji Pharma	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000
4	Xiwang Sugar	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000
5	Zhucheng Yuanfa	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
6	Weifang Jianbao	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
7	Qingdao Kehai	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
8	Shandong Kaixiang	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
9	Zhejiang Wulong	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
10	Xinxiang Zhongxin	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
11	Zhejiang Tianyi	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
12	Deqing Yuansu	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
13	Yuxing Biotechnology	/	200,000	200,000	200,000	200,000	200,000	200,000	200,000
14	Heilongjiang Zhonglang	/	/	/	/	100,000	100,000	100,000	100,000
15	Anhui BBCA	/	/	/	/	10,000	10,000	10,000	10,000
Others		51,800	51,800	51,800	30,000	30,000	30,000	30,000	30,000

Total	**1,036,800**	**1,236,800**	**1,236,800**	**1,315,000**	**1,355,000**	**1,355,000**	**1,355,000**	**1,355,000**

Source: CCM

In the future, the demand for GDL is expected to increase steadily. However, due to the rapid growth of domestic production capacity in recent years, the expansion of GDL production may slow down in the next few years.

Yuxing Biotechnology's 10,000 t/a GDL project and Hebei Zhaorang's 12,000 t/a GDL and gluconate construction (including 10,000 t/a GDL) project are estimated to be accomplished within this year, bringing the total GDL capacity in China to 122,000 t/a in 2024.

Table 3-2 Forecast on GDL capacity in China to 2027

No.	Producer	Capacity, t/a							
		2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
1	Shandong Xinhong	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
2	Shandong Kaixiang	12,000	12,000	15,000	15,000	15,000	15,000	15,000	15,000
3	Jining Guangji Pharma	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
4	Zhejiang Tianyi	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
5	Anhui Xingzhou	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
6	Jiangxi New Huanghai	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
7	Dezhou Huiyang	3,000	3,000	3,000	20,000	20,000	20,000	20,000	20,000
8	Shandong Liujiangyuan	/	7,500	7,500	7,500	7,500	7,500	7,500	7,500
9	Shandong Zhongxing	/	/	/	17,500	17,500	17,500	17,500	17,500
10	Yuxing Biotechnology	/	/	/	/	10,000	10,000	10,000	10,000
11	Hebei Zhaorang	/	/	/	/	10,000	10,000	10,000	10,000
12	Yichang Angel	/	/	/	/	/	N/A	N/A	N/A
Others		12,000	4,000	4,000	1,000	1,000	1,000	1,000	1,000
Total		**68,000**	**67,500**	**70,500**	**102,000**	**122,000**	**122,000**	**122,000**	**122,000**

Source: CCM

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