

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. During the past two years, these two industries have seen increasing output and consumption in China.

- Sodium gluconate

As of Dec. 2021, there were five manufacturers with sodium gluconate capacity exceeding 100,000 t/a, including Shandong Fuyang, Zhucheng Xingmao, Baisheng Biotechnology, Xiwang Sugar and the newcomer Yuxing Biotechnology. In 2017–2021, the output of sodium gluconate in China grew at a CAGR of 2.0%, reaching 701,400 tonnes in 2021. The output of the top five SG producers in 2021 accounted for 82.98% of total SG output in China, which was 5.44% lower than that of 2020.

In 2021, the full-year ex-works price of sodium gluconate was above USD660/t as USD/CNY continued to weaken. The price surpassed USD700/t in Q4 and reached USD779/t in Nov. as the price of corn starch rose.

As to SG production technology, the enzyme method has become the mainstream technology thanks to no fungal residue and less energy consumption.

- Glucono-delta-lactone

As of Dec. 2021, there were seven active GDL producers in China. The capacity of the top three producers accounted for 60.66% of the national total. Thanks to increasing demand abroad and profitable sales, the output of GDL in China grew at a CAGR of 2.34% from 2017 to 2021, reaching 34,000 t/a in 2021. From 2018 to 2021, China's GDL operating rate remains between 55%–60% (except for 2020).

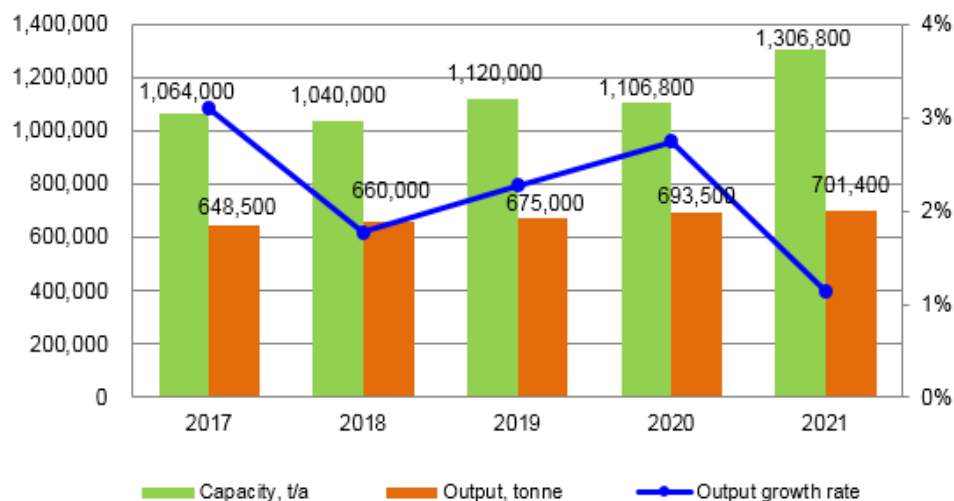
In 2021, annual average ex-works price of GDL reached USD1,687/t, rising 19.22% year on year.

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 starting material.

1 Production of sodium gluconate in China, 2021

1.1 Production

Figure 1.1-1 Capacity and output of sodium gluconate in China, 2017–2021



Source:CCM

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

However, with the launch of Shandong Fuyang's expansion project in May 2019, China's sodium gluconate capacity increased to 1,120,000 t/a. In 2021, this figure rose to 1,306,800 t/a as Yuxing Biotechnology entered the market and its 200,000 t/a sodium gluconate expansion project was completed and went into operation.

In 2017–2021, the output of sodium gluconate in China grew at a CAGR of 2.0%, reaching 701,400 tonnes in 2021. The increasing fixed assets investment in China and higher requirements for concrete have been supporting the domestic demand for sodium gluconate in recent years.

1.2 Major producers

Overall, the concentration of SG production gradually dispersed from 2019 to 2021, mainly due to the changes in the competitiveness of large enterprises.

As of Dec. 2021, there were five manufacturers with sodium gluconate (SG) capacity exceeding 100,000 t/a, namely Shandong Fuyang, Zhucheng Xingmao, Baisheng Biotechnology, Xiwang Sugar and the newcomer Yuxing Biotechnology. The output of the top five SG producers in 2021 accounted for 82.98% of total SG output in China, which was 5.44% lower than that of 2020.

For one thing, the government has paid more attention to the environmental protection in the past few years and will continue to introduce stricter rules in the future. Some SG producers have been or will be eliminated from the market because of environmental and economic factors. For the other thing, the development of China's construction industry and the profit of SG have encouraged the producers to enlarge their capacity, with some big players seeking to gain more market share.

With the entry and exit of players, China's SG production has increasingly concentrated in the north of China, mainly in the corn-planting regions such as Shandong and Hebei provinces.

Table 1.2-1 Major sodium gluconate producers in China, as of April 2022

No.	Producer	Abbreviation	Location	Produce glucono-delta-lactone, Yes/No	Status, as of April 2022
1	Shandong Fuyang Biotechnology Co., Ltd.	Shandong Fuyang	Shandong	Yes	Active
2	Zhucheng Xingmao Corn Developing Co., Ltd.	Zhucheng Xingmao	Heilongjiang, Inner Mongolia	No	Active
3	Yuxing Biotechnology(Group) Co., Ltd.	Yuxing Biotechnology	Hebei	No	Active
4	Shandong Baisheng Biotechnology Co., Ltd.	Baisheng Biotechnology	Shandong	Yes	Idle
5	Shandong Xiwang Sugar Co., Ltd.	Xiwang Sugar	Shandong	No	Active
6	Zhucheng Shuguang Biotechnology Co., Ltd.	Zhucheng Shuguang	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
14	Xinxiang Huaxing Biotech Co., Ltd.	Xinxiang Huaxing	Henan	No	Suspended

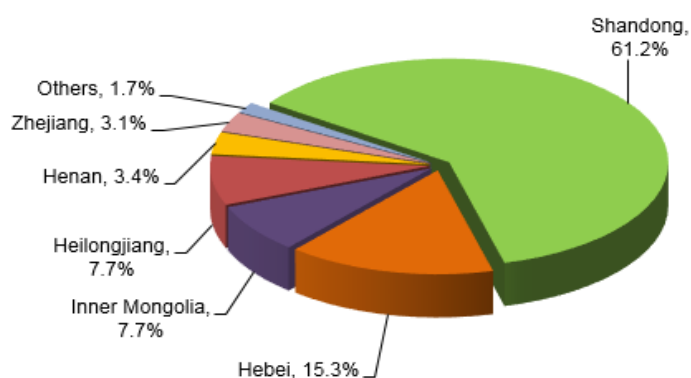
Source:CCM

Table 1.2-2 Capacity and output of major sodium gluconate producers in China, 2018–2021

No.	Producer	Capacity, t/a				Output, tonne							
						2021		2020		2019		2018	
		2021	2020	2019	2018	Solid	Liquid	Solid	Liquid	Solid	Liquid	Solid	Liquid
1	Shandong Fuyang	250,000	250,000	250,000	150,000	224,000	0	220,000	0	200,000	0	150,000	0
2	Zhucheng Xingmao	200,000	200,000	200,000	200,000	126,000	8,500	129,000	7,500	119,000	7,500	120,000	7,500
3	Yuxing Biotechnology	200,000	/	/	/	82,000	0	/	/	/	/	/	/
4	Baisheng Biotechnology	150,000	150,000	150,000	150,000	32,000	2,000	105,000	6,000	148,000	9,500	150,000	9,000
5	Xiwang Sugar	120,000	120,000	120,000	120,000	107,000	0	115,000	0	105,000	0	110,000	0
6	Zhucheng Shuguang	100,000	100,000	100,000	100,000	43,000	0	44,200	0	32,000	0	37,900	0
7	Weifang Jianbao	100,000	100,000	100,000	100,000	32,000	0	35,000	0	28,000	0	33,000	0
8	Qingdao Kehai	50,000	50,000	50,000	50,000	12,000	0	0	0	0	0	0	0
9	Shandong Kaixiang	30,000	30,000	30,000	50,000	29,000	3,000	30,000	2,500	29,000	2,500	40,000	2,800
10	Zhejiang Wulong	30,000	30,000	30,000	30,000	3,000	0	2,500	0	2,000	0	2,000	0
11	Zhejiang Tianyi	6,000	6,000	6,000	6,000	4,900	0	5,000	0	4,300	0	4,800	0
12	Deqing Yuansu	4,000	4,000	4,000	4,000	2,500	400	3,000	400	2,800	400	3,300	400
13	Xinxiang Zhongxin	15,000	15,000	15,000	15,000	0	0	800	100	1,000	200	1,000	200
14	Xinxiang Huaxing	30,000	30,000	30,000	30,000	0	0	0	0	0	0	3,000	0
Others		21,800	21,800	35,000	35,000	4,000	3,000	4,000	3,000	3,900	10,500	5,000	9,500
Total		1,306,800	1,106,800	1,120,000	1,040,000	701,400	16,900	693,500	19,500	675,000	30,600	660,000	29,400

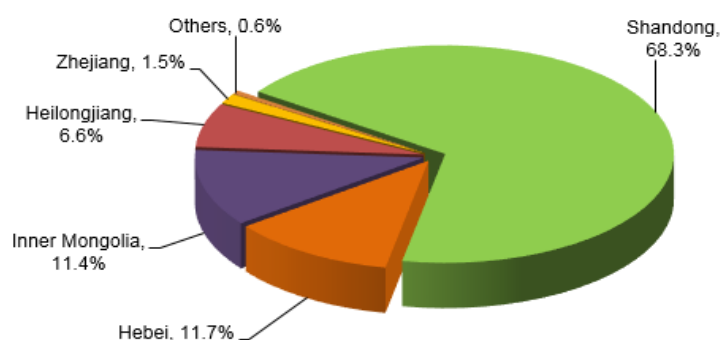
Source:CCM

Figure 1.2-1 Capacity distribution of sodium gluconate in China, 2021



Source:CCM

Figure 1.2-2 Output distribution of sodium gluconate in China, 2021



Source:CCM

In Jan. 2019, Shandong Kaixiang's SG technical transformation project (SG capacity decreased from 50,000 t/a to 30,000 t/a) was completed. In May 2019, Shandong Fuyang's 100,000 t/a SG expansion plan was built up and put into production.

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

In 2021, Yuxing Biotechnology completed the new construction of 200,000 t/a SG project in Xingtai City, Hebei Province and began to put into production. Due to the shortage of working capital, Baisheng Biotechnology has been restructuring its business, resulting in limited production in 2021.

There are also four potential SG producers in China, namely Qingzhou Huakang Biotechnology Co., Ltd. (Qingzhou Huakang), Heilongjiang Zhonglang Biotechnology Co., Ltd. (Heilongjiang Zhonglang), Anhui BBKA Biochemical Co., Ltd. (Anhui BBKA) and Dezhou Heyang Biotechnology Co., Ltd. (Dezhou Heyang).

- The environmental impact assessment (EIA) report of Qingzhou Huakang's 85,000 t/a SG project was submitted to the local government in April 2019, but this project hasn't started as

of April 2022.

- Heilongjiang Zhonglang's corn deep-processing project (300,000 t/a corn starch, 100,000 t/a SG, and 50,000 t/a itaconic acid) was under construction, which is planned to be built up in 2022.
- The EIA report of Anhui BBKA's 50,000 t/a SG project was publicised on March 15, 2022.
- Dezhou Heyang, a subsidiary of Shandong Fuyang, made the second public announcement for the EIA report of a 200,000 t/a SG project on April 6, 2022, and the expected operational date is Jan. 2024.

Link of expansion project:

http://www.qingzhou.gov.cn/xxgk/SHBJ/201904/t20190418_470129.htm

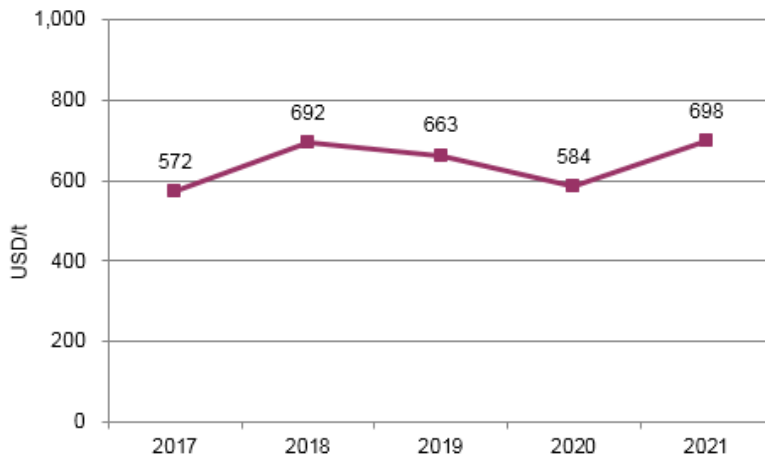
http://www.qth.gov.cn/qthzfxgk/fdzdgknr/zdxi_6465/202010/t20201030_283676.htm

<http://www.bengbu.gov.cn/public/25821/49668066.html>

<http://www.dzhibkys.cn/index.php/content/1229>

1.3 Price

Figure 1.3-1 Annual average ex-works price of sodium gluconate in China, 2017–2021



Source:CCM

Table 1.3-1 Ex-works price of sodium gluconate by major producers in China, April 2022

No.	Producer	Food grade		Industrial grade	
		RMB/t	USD/t	RMB/t	USD/t
1	Shandong Fuyang	5,050	795	5,050	795
2	Zhucheng Xingmao	4,650	732	/	/
3	Yuxing Biotechnology	4,700	740	4,700	740
4	Zhucheng Shuguang	4,850	764	/	/
5	Qingdao Kehai	5,000	787	4,800	756
6	Shandong Kaixiang	5,500	866	5,200	819
7	Zhejiang Tianyi	6,500	1,023	6,300	992

Source:CCM

Affected by the increasing price of corn starch and the tightening environmental regulation, the ex-works price of sodium gluconate has surged since H2 2017. In April 2018, the average ex-works quotation of sodium gluconate by major producers in Shandong Province exceeded USD680/t, up by about 27.8% year on year from USD532/t.

In 2019, as the price of raw material corn came down, the annual average ex-works price of sodium gluconate dropped to USD663/t, down 4.2% year on year.

In 2020, the annual average ex-works price dropped a lot to USD584/t, due to factors as the outbreak of COVID-19, sufficient supply of sodium gluconate, stronger USD against CNY, etc.

In 2021, the full-year ex-works price of sodium gluconate was above USD660/t as USD/CNY continued to weaken. The price surpassed USD700/t in Q4 and reached USD779/t in Nov. as the price of corn starch rose.

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.

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, the product is not allowed to be used as food additives in food production. Therefore, the development of 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.

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 Biotechnology Co., Ltd. started to adopt the enzyme method in sodium gluconate production in 2016 and 2018, respectively. In 2019, Qingzhou Huakang, a potential producer, also chooses this method to produce SG. No fungal residue is generated during the process of sodium gluconate production by enzyme method, overcoming the disadvantage of impure products produced by bio-fermentation. Besides, this method consumes less energy than the bio-fermentation method.

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

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

Manufacturing principle of various sodium gluconate production methods

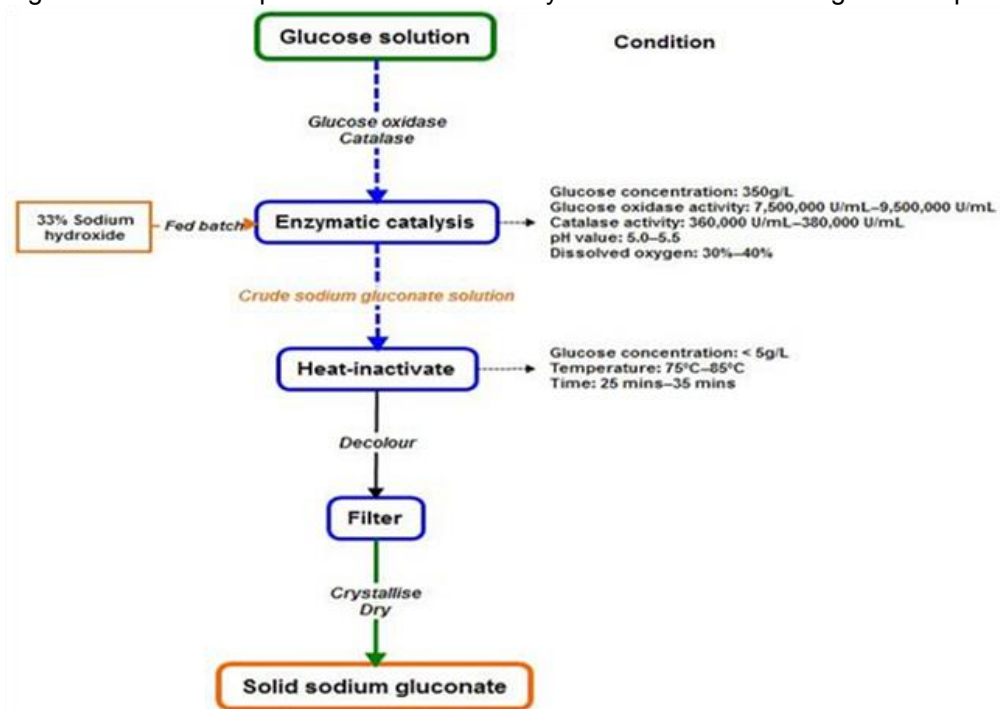
- Catalytic oxidation method: Oxidate glucose solution into gluconic acid using a metal catalyst, add sodium hydroxide to neutralise gluconic acid into sodium gluconate.
- Bio-fermentation method: Using *Aspergillus niger* to ferment glucose solution into gluconic acid, add sodium hydroxide to neutralise 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 neutralise 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, 2021

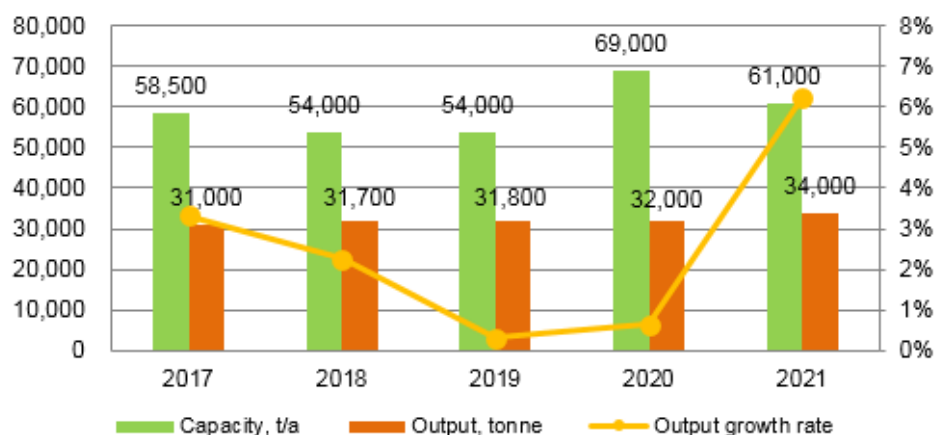
Production method	Producer
Bio-fermentation method	Shandong Fuyang, Zhucheng Xingmao, Baisheng Biotechnology, Xiwang Sugar, Zhucheng Shuquang, Xinxiang Zhongxin, Zhejiang Tianyi, Qingdao Kehai
Enzyme method	Weifang Jianbao, Shandong Kaixiang, Yuxing Biotechnology
Catalytic oxidation method	Zhejiang Wulong, Guangdong Redwall, Deqing Yuansu, Xinxiang Huaxing

Source: CCM

2 Supply of glucono-delta-lactone in China, 2021

2.1 Production

Figure 2.1-1 Capacity and output of GDL in China, 2017–2021

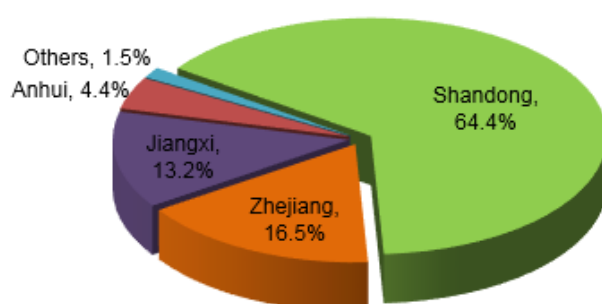


Source:CCM

From 2017 to 2021, only Shandong Xinhong expanded its capacity, bringing China's GDL capacity to 69,000 t/a in 2020. However, due to the increasingly stricter environmental production inspections during this period, Zhangshu Guanyi, Shanggao Jinyang and Yibin GraceBIO suspended or stopped production, and then the GDL capacity was reduced to 61,000 t/a in 2021.

Thanks to increasing demand abroad and profitable sales, the output of GDL in China grew at a CAGR of 2.34% from 2017 to 2021, reaching 34,000 t/a in 2021. From 2018 to 2021, China's GDL operating rate remains between 55%–60% (except for 2020, due to the completion of Shandong Xinhong's GDL expansion project in Oct. 2020).

Figure 2.1-2 Output distribution of GDL in China, 2021



Source:CCM

Shandong Province is a major producing region for GDL and its raw materials—glucose and sodium gluconate. In 2021, Shandong's GDL output accounted for 64.4% of the national total.

As of Dec. 2021, there were seven active GDL producers in China. The capacity of the top three producers accounted for 60.66% of the national total. State-owned companies rarely enter the GDL market because GDL is not an important product affecting people's livelihood. As of Dec. 2021, there was no foreign investment in China's GDL industry and most Chinese GDL enterprises were private. So far, the Chinese government has no intention to restrict their operations.

Table 2.1-1 Basic information about GDL producers in China, 2021

No.	Producer	Abbreviation	Status 2021	Location	Launch time
1	Shandong Xinhong Pharmaceutical Co., Ltd.	Shandong Xinhong	Active	Shandong	2020
2	Shandong Kaixiang Biochemical Co., Ltd.	Shandong Kaixiang	Active	Shandong	2006
3	Shandong Hongsheng Biotechnology Co., Ltd.	Shandong Hongsheng	Active	Shandong	2014
4	Zhejiang Tianyi Food Additives Co., Ltd.	Zhejiang Tianyi	Active	Zhejiang	2011
5	Anhui Xingzhou Medicine & Food Co., Ltd.	Anhui Xingzhou	Active	Anhui	2003
6	Jiangxi New Huanghai Food Co., Ltd.	Jiangxi New Huanghai	Active	Jiangxi	2003
7	Dezhou Huiyang Biotechnology Co., Ltd.	Dezhou Huiyang	Active	Shandong	2014
8	Zhangshu Guanyi Food Additive Co., Ltd.	Zhangshu Guanyi	Idle	Jiangxi	2008

Source:CCM

Table 2.1-2 Capacity and output of GDL producers in China, 2018–2021

No.	Producer	Capacity, t/a				Output, tonne			
		2021	2020	2019	2018	2021	2020	2019	2018
1	Shandong Xinhong	15,000	15,000	/	/	6,400	2,000	/	/
2	Shandong Kaixiang	12,000	12,000	12,000	12,000	7,000	6,500	6,000	5,300
3	Shandong Hongsheng	10,000	10,000	10,000	10,000	5,500	8,000	9,600	9,400
4	Zhejiang Tianyi	6,000	6,000	6,000	6,000	5,600	5,500	5,200	5,000
5	Anhui Xingzhou	6,000	6,000	6,000	6,000	1,500	0	0	0
6	Jiangxi New Huanghai	5,000	5,000	5,000	5,000	4,500	4,500	4,500	4,400
7	Dezhou Huiyang	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
8	Zhangshu Guanyi	3,000	3,000	3,000	3,000	0	0	0	0
	Others	1,000	9,000	9,000	9,000	500	2,500	3,500	4,600
	Total	61,000	69,000	54,000	54,000	34,000	32,000	31,800	31,700

Source:CCM

In 2018–2020, Anhui Xingzhou suspended production due to environmental protection inspections and produced a small amount of GDL in 2021. At present, it sells GDL products of Shandong Hongsheng, Shandong Kaixiang and Dezhou Huiyang as an agent.

In Oct. 2020, due to the completion of its 18,000 t/a gluconate project, Shandong Xinhong's GDL capacity added 15,000 t/a. In 2021, Shandong Xinhong became the producer with the largest capacity and the second largest output.

The largest GDL producer by output in 2021 was Shandong Kaixiang, which typically sells GDL through Anhui Xingzhou. In July 2021, the EIA report of Shandong Kaixiang's GDL technical transformation project was publicised, and the GDL capacity was planned to be increased from 12000 t/a to 15000 t/a; the construction is scheduled to be completed in 12 months.

Link of expansion project:

http://www.wulian.gov.cn/art/2021/7/5/art_34021_10293546.html

There are also three potential GDL producers in China: Hebei Yuxing, Shandong Liujiangyuan Food Technology Co., Ltd. (Shandong Liujiangyuan) and Angel Yeast (Yichang) Co., Ltd. (Yichang Angel).

- Hebei Yuxing acquired planning permit for construction land use for the 10,000 t/a GDL project in Dec. 2020, but the project has not been completed until April 2022.

Link of expansion project:

<https://www.ningjin.gov.cn/xxgk/content/27007.html>

- In July 2021, the EIA of 10,000 t/a gluconic acid project of Shandong Liujiangyuan was approved by local authorities. The project is divided into two phases, with a production scale of 7,500 t/a GDL and 1,000 t/a 50% glucose solution in phase I.

Link of expansion project:

http://www.wenshang.gov.cn/art/2021/7/29/art_20173_2716261.html

http://xxgk.wenshang.gov.cn/art/2021/7/21/art_20172_2716228.html

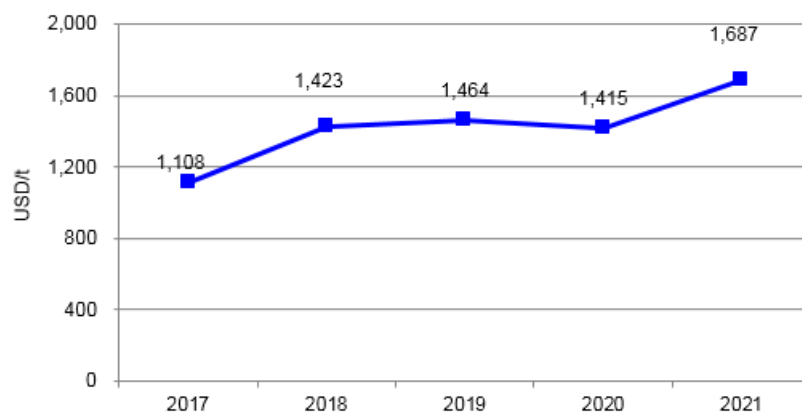
- In Dec. 2021, Angel Yeast Co., Ltd. announced that its subsidiary Yichang Angel would implement the 150,000 t/a hydrolyzed sugar deep processing project. Of this amount, 115,000 t/a hydrolyzed sugar is used for yeast fermentation and 35,000 t/a for the production of GDL and other deep processing projects. This project is planned for two phases: the construction of hydrolyzed sugar workshop in phase I and the construction of GDL production line in phase II. But the company has not yet unveiled the design production 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>

2.2 Price

Figure 2.2-1 Annual average ex-works price of GDL in China,2017–2021



Source:CCM

In 2017, the production of GDL was affected because of stricter environmental protection inspections. As a result, the ex-works price of GDL began to rise at the end of 2017 due to short supply.

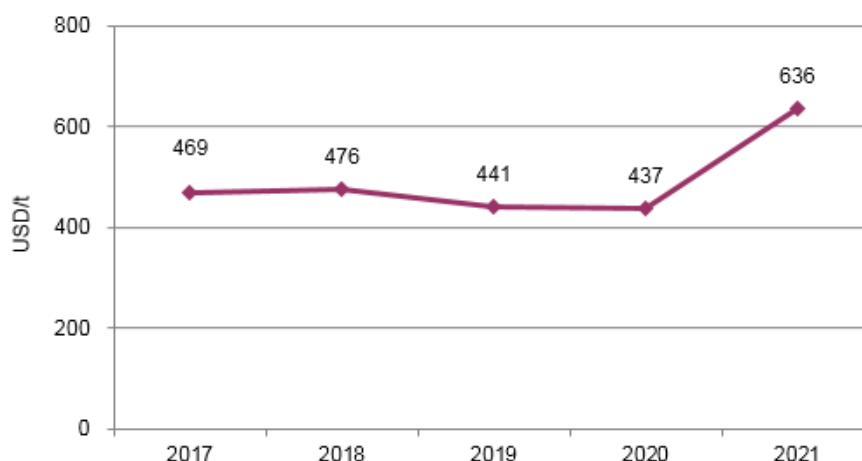
In 2018, the annual average ex-works price of GDL increased by 28.4% year on year. Besides, there were only seven active GDL producers in China, and Anhui Xingzhou had strong pricing power after taking charge of a large part of domestic GDL sales.

As people's health consciousness constantly enhanced, the demand for GDL, a harmless food additive to the human body, grew 2%–4% annually 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, the annual average ex-works price of GDL reached USD1,687/t, rising 19.22% year on year.

Figure 2.2-2 Annual average ex-works price of glucose monohydrate in China, 2017–2021



Source:CCM

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

Before 2016, ex-works prices of glucose and its raw material—corn starch had been kept at a high level. In 2016, the Chinese government cancelled the temporary purchase and storage policy on corn, leading to a tumble of corn price. Ex-works price of glucose plunged, too. Due to increasing demand for glucose, the price has rebounded since 2017. Besides, in April 2017, the National Development and Reform Commission issued a notice to rescind the restrictions on new corn deep processing projects, which encouraged producers in this sector to put new capacity into production.

In 2018, as prices of raw material corn and corn starch went up, the cost of starch sugar increased. The annual average ex-works price of glucose monohydrate was USD476/t, edging up 1.5% year on year.

However, in 2019, the price of corn was down by 3.0% year on year, primarily due to lower demand for corn feed caused by African swine fever. As a result, the price of glucose monohydrate reduced by 7.4% year on year.

In 2020, the price of glucose monohydrate fell in H1 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 remained high throughout the year. It rose to a peak of USD681/t in Feb. before falling back. In Q4, as the price of corn rose, it recovered to around USD655/t.

2.3 Production technology

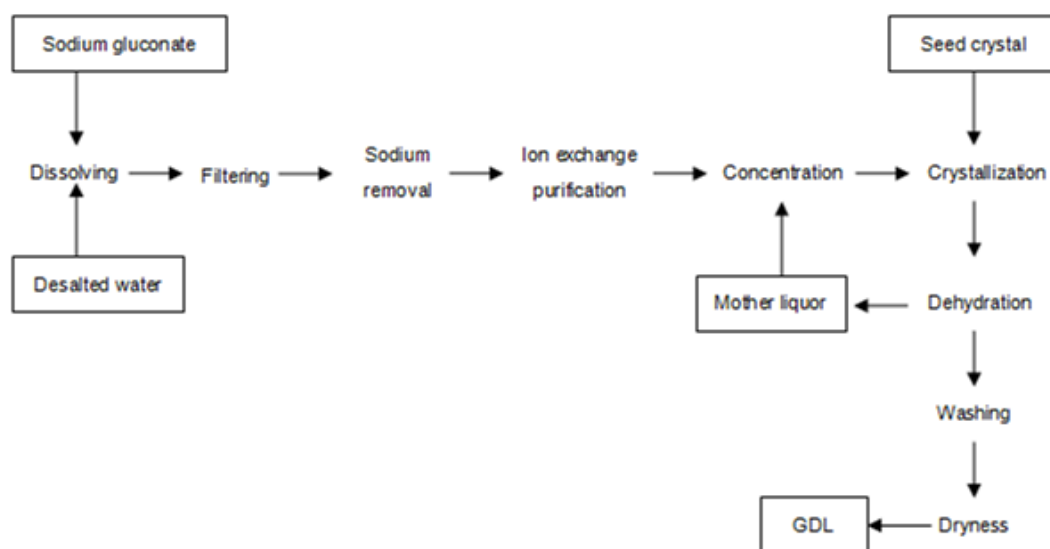
2.3.1 Different pathways/methods

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 starting material. The other three production methods except the fermentation method are seldom used because of their exorbitant production cost and high energy consumption.

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) at first, and eventually turning into GDL. Currently, only the last two paths namely the SG method and CG method are applied in China.

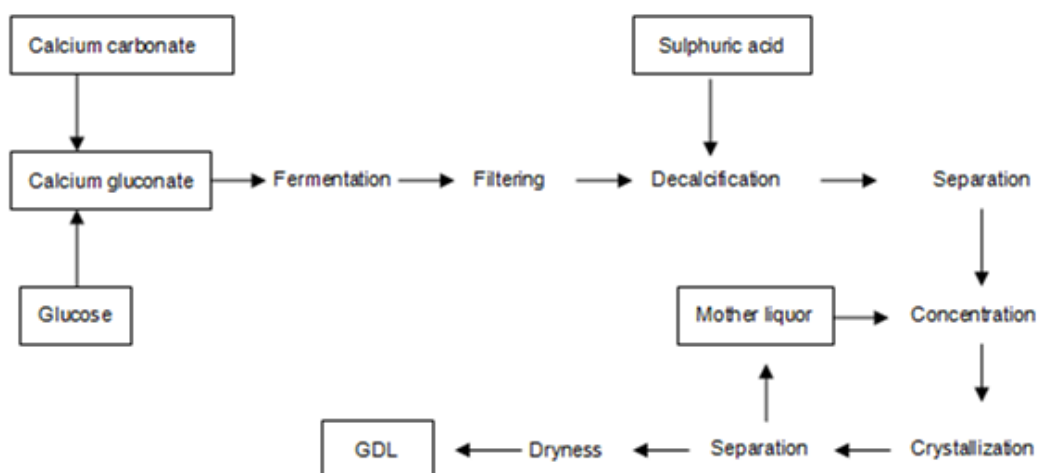
In the fermentation method, glucose or maltose is used as starting material. In China, glucose is made into glucose solution first, then transferred to calcium gluconate or sodium gluconate after fermentation, and made into GDL finally. Dezhou Huiyang adds trehalase into maltose solution (75%) to get the mixture of trehalose and maltose first, then gets the mixture of trehalose and glucose by adding glucose oxidase, and gets GDL after further processing finally. Shandong Xinhong uses glucose oxidase to convert glucose into gluconic acid and then uses the crystallization method to extract GDL.

Figure 2.3.1-1 Flowchart of sodium gluconate method in China



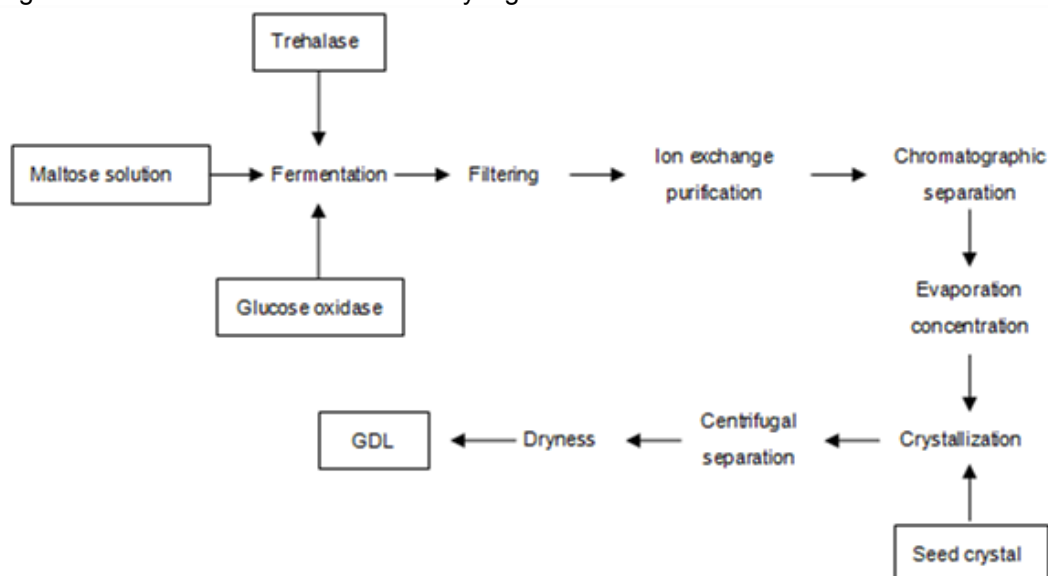
Source:CCM

Figure 2.3.1-2 Flowchart of calcium gluconate method in China



Source:CCM

Figure 2.3.1-3 Flowchart of Dezhou Huiyang's GDL method



Source:CCM

Table 2.3.1-1 Production method of GDL by producer in China, 2021

No.	Producer	Technology	Raw	Raw material source
1	Shandong Hongsheng	SG method	SG	Shandong Baisheng Biotechnology Co., Ltd.
2	Shandong Kaixiang	SG method	SG	Captive
3	Shandong Xinhong	Glucose oxidase	Glucose	Outsourcing
4	Zhejiang Tianyi	Fermentation method	Glucose	Outsourcing
5	Jiangxi New Huanghai	Fermentation method	Glucose	Outsourcing
6	Dezhou Huiyang	Fermentation method	Maltose	Captive

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.

Four 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 adopts the method developed by its affiliated company—Shandong Fuyang Biotechnology Co., Ltd.
- Jiangsu Huanyu Kangli Technology Co., Ltd. (Jiangsu Kangli) adopts its own designed methods and equipment to produce GDL (usually for its own use). And Jiangsu Zhuoyun Doubao Food Co., Ltd. (Jiangsu Zhuoyun Doubao) is its affiliated company.

Two preparation methods (developed by China Tobacco Hubei Industrial LLC and Jinan University) are suitable for pilot-line production only.

Two production methods (developed by Xu Jiaying and Zhu Zhongliang) are not adopted by the domestic GDL producers.

Table 2.3.2-1 Patents related to GDL production applied in China, as of April 2022

No.	Patent	Application No.	Applicant	Date of application
1	A production process and equipment for preparing GDL from sodium gluconate	CN202111232278.8	Jiangsu Kangli	Oct. 2021
2	A method for utilization and treatment of high salt ion exchange wastewater of GDL	CN202111021913.8	Shandong Kaixiang	Sept. 2021
3	A production equipment for GDL	CN202023350467.9	Jiangsu Zhuoyun Doubao	Dec. 2020
4	A production method of GDL	CN202011539600.7	Jiangsu Zhuoyun Doubao	Dec. 2020
5	A production and concentration device for GDL	CN202022637087.7	Jiangsu Zhuoyun Doubao	Nov. 2020
6	A drying equipment for GDL production	CN202021659278.7	Jiangsu Kangli	Aug. 2020
7	A preservation device of GDL crystal	CN201922096229.0	Jiangxi New Huanghai	Nov. 2019
8	A agitated reaction vessel for GDL	CN201922096241.1	Jiangxi New Huanghai	Nov. 2019
9	A crystallization equipment for GDL	CN201922096226.7	Jiangxi New Huanghai	Nov. 2019
10	A mixing tank with cleaning device for GDL	CN201922085295.8	Jiangxi New Huanghai	Nov. 2019
11	A steam recovery and utilization device for GDL	CN201922085616.4	Jiangxi New Huanghai	Nov. 2019

12	A dryer for GDL	CN201922085634.2	Jiangxi New Huanghai	Nov. 2019
13	A monitoring sensor for GDL	CN201922095136.6	Jiangxi New Huanghai	Nov. 2019
14	A vacuum concentration device for GDL	CN201921158618.5	Jiangsu Kangli	July 2019
15	A preparation method of GDL and its application in essence for tobacco	CN201711089899.9	China Tobacco Hubei Industrial LLC	Nov. 2017
16	A production method of GDL	CN201710300026.1	Xu Jiaying	May 2017
17	A steam recovery and utilization unit for GDL evaporation concentration production line	CN201720360449.8	Shandong Kaixiang	April 2017
18	A method of preparing trehalose and GDL at the same time	CN201610710587.4	Shandong Fuyang	Aug. 2016
19	An on-line monitoring device for ion exchange method of GDL production	CN201520917513.9	Jiangsu Kangli	Nov. 2015
20	A production method of GDL	CN201410618065.2	Zhu Zhongliang	Nov. 2014
21	A GDL evaporation concentration equipment	CN201420225686.X	Nanjing Gaojie Light Industrial Equipment Co., Ltd.	May 2014
22	An energy-saving concentration method and equipment of GDL	CN201110409395.7	Shandong Kaixiang	Dec. 2011
23	A preparation method of GDL	CN201110338402.9	Jinan University	Oct. 2011
24	A production method of GDL	CN200910192646.3	Xiamen Starmem Technology Co., Ltd.	Sept. 2009

Source: National Intellectual Property Administration, PRC

3 Forecast on sodium gluconate and GDL production in China

As the demand for sodium gluconate at home and abroad has been growing steadily, although the domestic supply can basically meet the demand, there are still some enterprises planning to build new projects of sodium gluconate. These projects are often taken as a project for the extension of the corn deep-processing industrial chain.

If it goes well, the production capacity of sodium gluconate may exceed 1,450,000 t/a in 2023. With the completion of Shandong Fuyang's 200,000 t/a sodium gluconate project in 2024, the capacity will be over 1,700,000 t/a.

Table 3-1 Sodium gluconate capacity forecast to 2025

No.	Producer	Capacity, t/a							
		2018	2019	2020	2021	2022	2023	2024	2025
1	Shandong Fuyang	150,000	250,000	250,000	250,000	250,000	250,000	450,000	450,000
2	Zhucheng Xingmao	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000
3	Baisheng Biotechnology	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 Shuguang	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	50,000	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 Huaxing	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
11	Xinxiang Zhongxin	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
12	Zhejiang Tianyi	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
13	Deqing Yuansu	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
14	Yuxing Biotechnology	/	/	/	200,000	200,000	200,000	200,000	200,000
15	Heilongjiang Zhonglang	/	/	/	/	100,000	100,000	100,000	100,000
16	Anhui BBKA	/	/	/	/	/	50,000	50,000	50,000
17	Qingzhou Huakang	/	/	/	/	/	/	85,000	85,000
	Others	35,000	35,000	21,800	21,800	21,800	21,800	21,800	21,800
	Total	1,040,000	1,120,000	1,106,800	1,306,800	1,406,800	1,456,800	1,741,800	1,741,800

Source:CCM

As the demand for GDL exports continues to grow, new competitors will emerge in the coming years, resulting in increased GDL capacity. Yuxing Biotechnology's 10,000 t/a GDL project is estimated to be built up as early as 2022, while Shandong Liujiangyuan's 7,500 t/a GDL project is expected to be built up as early as 2023.

Table 3-2 GDL capacity forecast to 2025

No.	Producer	Capacity, t/a							
		2018	2019	2020	2021	2022	2023	2024	2025
1	Shandong Kaixiang	12,000	12,000	12,000	12,000	15,000	15,000	15,000	15,000
2	Shandong Hongsheng	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
3	Zhejiang Tianyi	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
4	Anhui Xingzhou	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
5	Jiangxi New Huanghai	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
6	Dezhou Huiyang	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
7	Zhangshu Guanyi	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
8	Shandong Xinhong	/	/	15,000	15,000	15,000	15,000	15,000	15,000
9	Yuxing Biotechnology	/	/	/	/	10,000	10,000	10,000	10,000
10	Shandong Liujiangyuan	/	/	/	/	/	7,500	7,500	7,500
11	Yichang Angel	/	/	/	/	/	N/A	N/A	N/A
Others		9,000	9,000	9,000	1,000	1,000	1,000	1,000	1,000
Total		54,000	54,000	69,000	61,000	74,000	81,500	81,500	81,500

Source:CCM

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