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## **Analysis of Chinese tilapia supply and demand without and with the COVID-19 epidemic impact**

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### **Abstract**

We analyzed the supply and demand for tilapia in China while assessing the future developmental trends. China has become the world's largest producer, exporter, and consumer of tilapia. China entered a period of rapid aquaculture development in the 1990s, and the tilapia supply has increased yearly. Tilapia products are mainly supplied to the international market, especially in the US. The global market for the Chinese tilapia has grown dramatically, but a downward trend occurred in 2019–2020. The Chinese domestic market demand is relatively stable, and even the COVID-19 epidemic did not significantly impact the supply and demand of tilapia. Internationally, it is expected that the demand for tilapia will decline considerably in the near future. However, this decline could be alleviated after the impact of the COVID-19 epidemic passes, and increasing demand will resume. The increased supply of Chinese tilapia might slow down or even decrease due to market uncertainty, the increasing constraints on natural resources, and the Chinese government's requirements for high-quality aquaculture environments.

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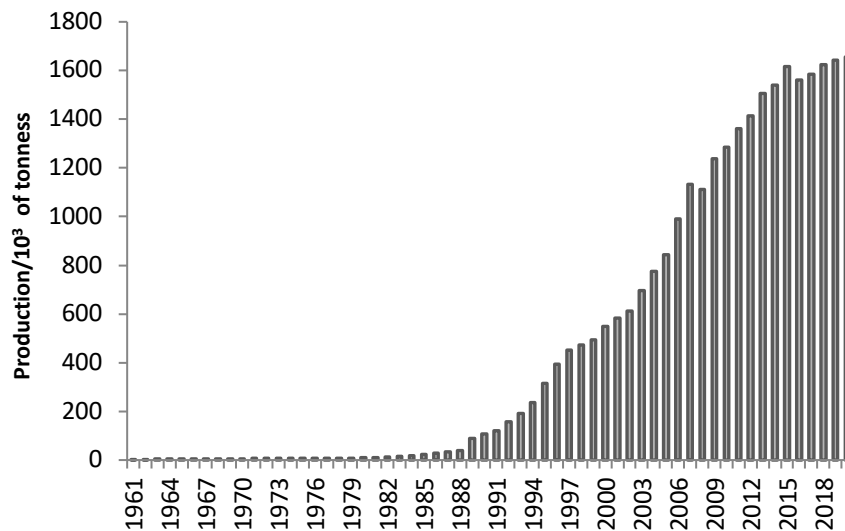
# *These authors contributed equally to this work*

## Introduction

China has been the largest country in fisheries and aquaculture production since 1988 (Food and Agriculture Organization, 2021). It accounted for over one-third of the world's fisheries and aquaculture production in 2019 (38.65%). The rapid growth of tilapia (*Oreochromis* spp.) production and export in China is essential for its dominance in the global aquaculture industry (Shelton, 2002). China is the world's largest producer, exporter, and consumer of tilapia (Chiu et al., 2013). The tilapia aquaculture industry has developed rapidly in China since the 1990s. Production increased from 0.12 million tonnes (1000 kg is a tonne or metric ton) in 1991 to 1.66 million tonnes in 2020, with an average annual growth rate of 9.48%, and it accounted for 23.74% of the global tilapia production in 2019 (Food and Agriculture Organization, 2021). In this study, we describe the development of the tilapia aquaculture industry, exports and domestic markets demand, its product mix, and exporting countries. The prospects of the tilapia industry are also discussed in the context of the COVID-19 epidemic.

## Tilapia supply in China

Tilapia aquaculture in China started in the 1960s and entered a period of rapid development after the 1990s, where the production from aquaculture has ranked first in the world since 1990 (Li et al., 2006). Production increased from 3,496 tonnes in 1961 to 1,655 thousand tonnes in 2020, with an average annual growth rate of 11%. The growth rate of tilapia production increased initially and then decreased. The average annual growth rate of tilapia production was 5.84% from 1961 to 1970, 4.21% from 1971 to 1980, and 29.86% from 1981 to 1990. The introduction and promotion of tilapia occurred from 1981–to 1990, but most farmers did not yet accept tilapia. Due to increased recognition by farmers, the aquaculture areas grew considerably, and tilapia production methods greatly improved, which increased production from 1991 to 2007, with an average annual growth rate of 15.08%. Since 2008, tilapia production's growth has slowed, with an average yearly growth rate of 3.88%. A relatively stable stage was reached from 2015 to 2018, with generally sound production at about 1.58 million tonnes. In 2019, production increased slightly compared with 2018, with an increase of 1.05%. The outbreak of the COVID-19 epidemic in 2020 did not significantly impact tilapia production in China, and production still increased by 0.84% in 2019 (**Figure 1**).



**Figure 1** Tilapia production globally and in China from 1961 to 2020.

In the initial stage (the 1960s and 1970s), the Mozambique tilapia species (*O. mossambicus*) was first introduced into China (Xia, 2000), but its large-scale promotion in aquaculture failed due to early maturation and high fecundity resulting in small adult fish (Li and Mair, 2003). During the tilapia culture development stage in China (the 1980s), Nile tilapia (*O. niloticus*) and hybrid tilapia (*Fu So Fish*) were preferred for aquaculture due to their advantages in terms of culture and production performance (Lai, 2003). At present, the GIFT (*Genetic Improvement of Farmed Tilapia*) strain of Nile tilapia and red tilapia (*O. spp.*) are mainly produced in China's market (Ming and Yi, 2004). The aquaculture environments include ponds, mountain ponds, reservoirs, and paddy (Ye, 2002; Afolabi, 2000). Tilapia is popular in China, and cultivated in 31 provinces, municipalities, and autonomous regions throughout the country. The production areas are mainly in Guangdong Province, Hainan Province, Guangxi Zhuang Autonomous Region, Yunnan Province, and Fujian Province, which account for more than 95% of the national production. Other regions, such as Hebei Province, Shandong Province, and Jiangxi Province, account for less than 5%. In 2020, the amounts of tilapia production by aquaculture in Guangdong Province, Hainan Province, Guangxi Zhuang Autonomous Region, Yunnan Province, and Fujian Province were 740, 318, 260, 170, and 120 thousand tonnes, respectively, which accounted for 44%, 19%, 16%, 10%, and 7% of the national tilapia aquaculture production (Fishery Administration, MARA, 2021). Tilapia farming started first in the Guangdong Province, now the most extensive farming area with the highest yield in China, followed by Hainan, Guangxi, Yunnan, and Fujian Provinces. In 2012, the size of tilapia aquaculture in Hainan exceeded that of Guangxi, while Hainan ranked second in the tilapia aquaculture area and production. In northern China, where the weather is cooler, the period suitable for tilapia growth is relatively short. Thus, tilapia farming in the north relies on geothermal resources to ensure they survive the winter, such as in Hebei and Shandong Provinces. Due to geographical reasons, tilapia prices have apparent advantages in southern China compared with northern regions (Fan, 2011).

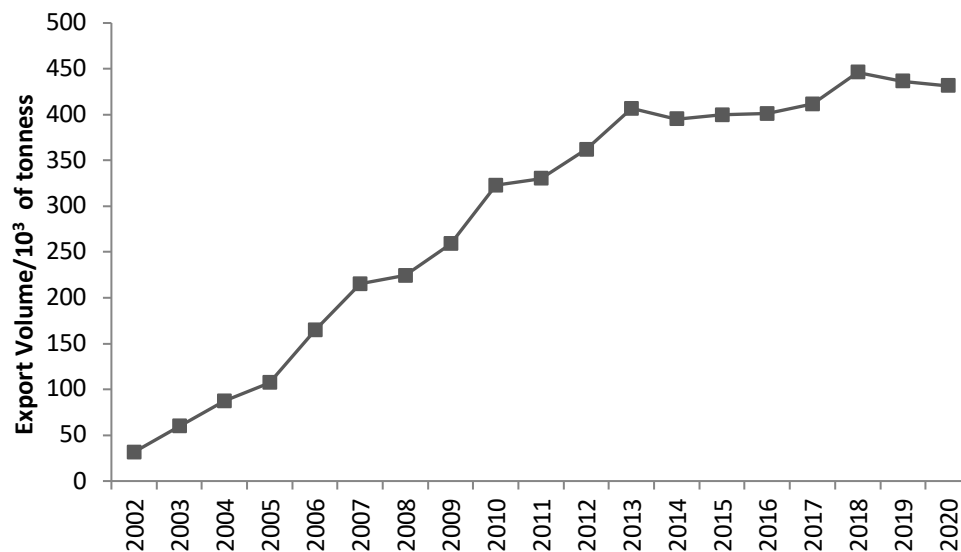
At the beginning of 2020, the outbreak of COVID-19 and the subsequent closure of roads and villages throughout China affected the tilapia industry, particularly in the seedling process (Rafiquzzaman, 2020). Winter and spring are the best seasons for the transportation of aquatic seedlings. The survival rate during the transportation is high, and the occurrence of diseases is low. However, the timing of seedling transportation and stocking was delayed due to the obstruction of transport. For example, tilapia fry production in Maoming City,

Guangdong Province, was reduced by more than half, and fry production declined sharply in Guangxi. In terms of processing, the blockage of transportation channels delayed fresh fish from reaching the processing plant, and thus the production requirements were not met. In addition, due to the lack of labor and coronavirus epidemic prevention equipment, most companies failed to start production as planned. After the World Health Organization defined COVID-19 as a public health emergency of international concern, many countries implemented immigration control. Thus, suitable air routes and shipping schedules could not be determined. Consequently, processing plants could not deliver their orders on time, resulting in problems such as contract breaches and customer claims. These problems were effectively alleviated in the second half of 2020 (Yuan et al., 2022).

## Demand for tilapia in China

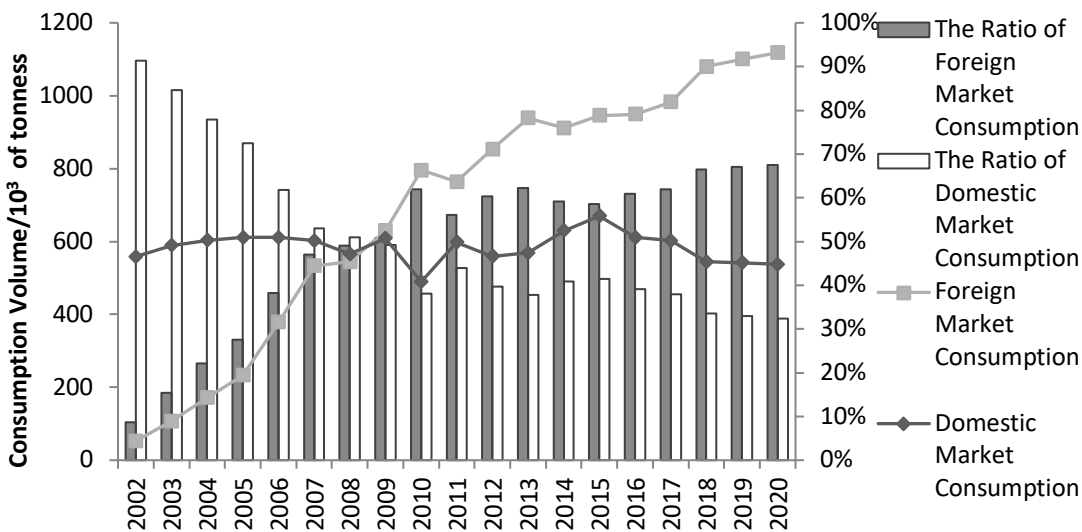
### 1. Comparison of demand in domestic and foreign markets

From 2002 to 2013, the foreign market demand for tilapia from China increased yearly, with an average annual growth rate of 26%. Demand began to decline in 2014 and remained relatively stable in the following four years, where it generally stabilized at around 400 thousand tonnes. Due to trade disputes between China and the United States, the United States began to impose a 10% tariff on Chinese tilapia products in September 2018, and this tariff share rose to 25% in May 2019. To avoid higher taxes in 2019, the demand for Chinese tilapia from US assembling wholesalers increased sharply in 2018. Consumption by the US market accounted for more than 30% of China's total export, which led to a substantial increase in the international market demand in 2018 (446 thousand tonnes). However, due to the rise in the tariff share, the demand decreased back to 436 thousand tonnes in 2019. Export orders decreased due to the dual impacts of the epidemic and Sino–the US trade war in 2020. Export quarantine procedures also became stricter, product costs increased, and tilapia export prices ultimately decreased to lower the farm gate prices. The export volume fell to 431 thousand tonnes (**Figure 2**).



**Figure 2** Tilapia export volumes from 2002 to 2020.

In studies by Chen (2006) and Dai (2014), tilapia products exported to the international market were converted into fresh fish. Their calculations of the global and domestic market consumption of tilapia in China are shown in **Figure 3**. In the early stage of tilapia's introduction in China, the products were mainly supplied to the domestic market, with low outputs and low export volumes. In 2002, domestic consumption exceeded 90% of the total production, which decreased yearly until 2010. Due to the significant increase in foreign market demand, the tilapia industry in China developed rapidly. After 2009, domestic consumption accounted for less than 50% of total production, and the tilapia market was transformed into an export-oriented industry. Since 2010, foreign demand has tended to increase each year. The foreign market consumption was 629,214 tonnes in 2009 and 1,118,183 tonnes in 2020, and its proportion of the total production also increased from 51% to 68% (**Figure 3**).



**Figure 3** Foreign and domestic market consumption of tilapia from 2002 to 2020.

Data source: China Fishery Statistical Yearbook; statistics from China Customs Department.

## 2. Demand for tilapia products

Tilapia products mainly include live tilapia, frozen tilapia, frozen tilapia fillets, prepared or preserved tilapia, chilled tilapia, and chilled tilapia fillets. In addition, small amounts of other products are made, such as tilapia skin, tilapia fingerlings, and tilapia scales.

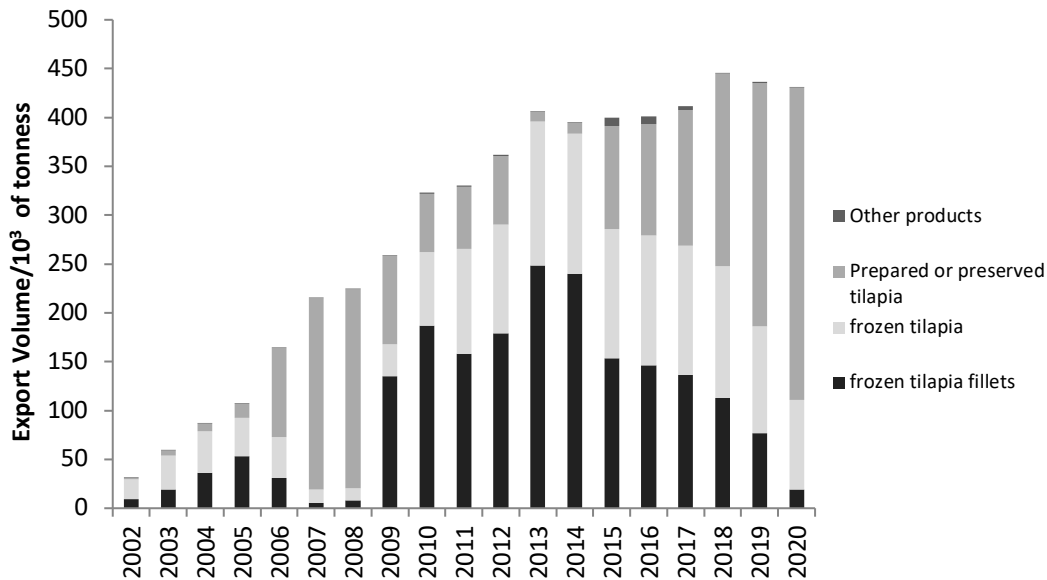
### (1) Domestic market

The domestic and foreign market demands for Chinese tilapia are pretty different. The domestic market is dominated by live fish, whereas processed products dominate the international market. In the early stage of the development of China's tilapia industry, live tilapia dominated domestic consumption. Due to the development of the catering industry, the tilapia market has gradually shifted to processed products, such as already cooked fish and tilapia fillets.

### (2) Foreign market

The changes in the foreign market demands for tilapia products are shown in **Figure 4**. The main exported products also changed from frozen tilapia to frozen tilapia fillets, followed by prepared or preserved tilapia. In 2002, the proportions of frozen tilapia fillets, frozen tilapia, prepared or preserved tilapia, live tilapia, and other tilapia products were 29%, 66%, 3%, 2%, and 0.2%, respectively, whereas the proportions in 2010 were 32%, 59%,

8%, 1%, and 0.1%, and the proportions in 2020 were 4%, 21%, 74%, 0.2%, and 0.002% (**Figure 4**).



**Figure 4** Changes in the exported product mix of tilapia products from 2002 to 2020. Data source: Statistics from China Customs Department.

### ① Frozen tilapia

Frozen tilapia used to dominate among the exported Chinese products. The consumption of frozen tilapia in the foreign market has gradually declined; thus, the export volume of frozen tilapia from China has also declined. Frozen tilapia fillets gradually became the main form of frozen tilapia. The consumption of frozen tilapia fell sharply from 2007 to 2008 but tended to increase again after 2009 when the highest volume of 147,749 tonnes was reached in 2013, and the average annual growth rate was 19% from 2002 to 2013. In subsequent years, consumption tended to decrease each year. In 2020, frozen tilapia consumption dropped to 92,070 tonnes, with an average annual growth rate of  $-7\%$  from 2013 to 2020.

### ② Frozen tilapia fillets

Since 2002, the export value of frozen tilapia fillets in the foreign market has exceeded that of frozen tilapia, which has stabilized at about 60% of the total export value. The foreign market's demand for Chinese frozen tilapia fillets increased initially before decreasing, growing again, and then decreasing. As shown in **Figure 4**, the tilapia fillet consumption by foreign markets in 2002 was 9 thousand tonnes, reaching 53 thousand tonnes in 2005. Due to the effect of the US market, the foreign demand for frozen tilapia fillets from China began to decrease in 2006, 71% less than that in 2005. After 2008, China's foreign demand for frozen tilapia fillets started to increase, and it gradually reached its highest level in 2013 (248 thousand tonnes). Subsequently, the need for frozen tilapia fillets in the foreign market declined. In 2020, the consumption of frozen tilapia fillets dropped to 19 thousand tonnes, which was 7% of the volume in 2013.

### ③ Prepared or preserved tilapia products

From 2002 to 2005, China's demand for prepared or preserved tilapia accounted for about 8% of the total export volume. In 2007–2008 when the need for frozen tilapia fillets and frozen tilapia decreased significantly, the prepared or preserved tilapia volume increased greatly, accounting for more than 90% of China's total export volume (**Figure 4**). In 2010–2012, the foreign demand for prepared or preserved tilapia stabilized at about 60 thousand tonnes, around 19% of China's total export volume. From 2013 to 2014, foreign demand for these products dropped significantly, and they only comprised 2% and 3% of the total volumes, respectively. Since 2015, the international market for prepared or preserved tilapia products has increased yearly, with an average annual growth rate of 75%, reaching 319 thousand tonnes in 2020.

### ④ Other tilapia products

In addition to frozen tilapia, frozen tilapia fillets, and prepared or preserved tilapia, the other exported tilapia products mainly comprise fresh and chilled tilapia, fresh and chilled tilapia fillets, salted tilapia, tilapia skin, tilapia fingerlings, and tilapia scales. The demand for these products is relatively small, accounting for less than 2% of the total export volume.

### 3. Countries with Chinese tilapia import

According to statistics from the China Customs Department, there has been a gradual increase in the number of countries where Chinese tilapia is exported. The number of countries that exported Chinese tilapia increased from over 10 in 2002 to 100 in 2020. The foreign market tends to be diversified. The main export destinations include the United States, Mexico, Ivory Coast, Israel, and Burkina Faso.

The United States is the leading country for Chinese tilapia exports. Chinese tilapia is highly dependent on the US market, but this dependence is gradually decreasing. The proportion of exports to the United States among the total exports has significantly reduced. In 2020, US exports accounted for 30% of the total exports compared with 45% in 2014. The demand in the United States has decreased each year since 2010. In 2010, the market was 16.82 thousand tonnes, but it decreased significantly in 2011. Exports stabilized at 17 thousand tonnes from 2012 to 2015 but decreased from 2016 to 2019, with an average annual growth rate of –6.29% (**Table 1**). However, instead of falling, exports rose by 2.37% in 2020.

**Table 1** Changes in the demand for tilapia by major countries from 2010 to 2020 (thousand tonnes).

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
U.S.	168.82	150.60	171.79	176.85	178.11	166.50	141.36	135.23	135.33	128.40	131.44
Mexico	43.21	46.84	39.40	53.78	51.57	49.52	62.43	60.17	79.98	80.55	88.39
Côte d'Ivoire	6.92	9.83	16.87	19.69	22.29	24.28	35.96	33.37	37.71	43.53	46.09
Israel	7.00	9.76	10.99	8.95	12.26	13.03	16.84	16.22	19.19	18.94	18.21
Burkina Faso	0.00	0.05	0.26	4.21	6.53	6.92	3.54	7.54	7.22	8.14	14.66
Kenya	0.15	0.21	0.29	0.68	1.24	3.77	8.32	12.40	15.06	9.50	9.71
Zambia	1.75	1.49	3.83	11.52	15.01	14.91	11.59	12.61	16.30	11.74	4.71
Russia	20.27	15.34	18.78	19.94	19.94	7.59	6.32	6.43	10.05	7.20	4.94
Cameroon	6.82	14.80	6.65	8.36	10.61	8.94	6.03	8.89	20.91	10.07	2.66
Iran	0.19	0.55	1.75	3.42	3.42	9.42	10.83	16.36	13.82	2.85	0.68

Data source: Statistics from China Customs Department.

Tilapia has successfully entered the European market as a substitute for traditional “white fish” (sturgeon and trout). In 2003, the demand was still zero in Russia, but the need for tilapia rose to third-ranked in 2010 (**Table 1**). At the same time, the market diversification strategy has been gradually implemented, and many Asian and African markets have been developed. The successful development of markets such as Ivory Coast, Israel, Zambia, and

Kenya has effectively alleviated the impact of the economic crisis on the tilapia industry in China. In addition, the structure of China's tilapia trade market may be optimized further.

## **Prospects for the tilapia industry in China**

### **1. Growing demand**

The global population continues to grow, and the international demand for aquatic products is increasing. This trend will not change in the next few decades. According to a United Nations report, the global population will reach 9.7 billion by 2050, which is 2 billion people more than in 2019, and the new population will be close to four times the world's total population in 1950. In addition, due to economic development and improved living standards, the proportion represented by the middle class has increased, with enhanced consumption levels. The global demand for aquatic products will affect the demand for tilapia. In addition, due to the global effects of epidemics such as bird flu, swine flu, and mad cow disease, consumers have turned to aquatic products to satisfy their protein requirements. Given these considerations, the global demand for tilapia will continue to grow. China is the largest global tilapia producer, and its domestic market has excellent prospects for development. However, the global economy has not entirely recovered from the downturn due to the COVID-19 epidemic, so it is expected that the demand for tilapia will decrease significantly for a short period (Miao, 2021; FAO, 2021). In January-April 2020, when the COVID-19 epidemic broke out, the supply of Chinese producers and processors slowed down significantly. In April, 25% tariffs on tilapia imported from China to the United States were removed, which softened the blow of the epidemic to some extent. Besides, due to the gradual easing of traffic restrictions, the decline of the Chinese tilapia industry caused by the COVID-19 epidemic will gradually ease, and the overall growth trend will resume.

### **2. Slowing supply**

China produced 1655 thousand tonnes of tilapia in 2020. The average annual growth rate from 2011 to 2020 was 2.19%. The rate has slowed down significantly compared with the average yearly growth rate of 9.92% from 2000 to 2010. In recent years, the methods used for tilapia aquaculture in China have developed rapidly, and the output per unit area has increased significantly. The optimal output value is gradually approaching, and increases in tilapia production will gradually slow down. Rising farming costs coupled with modest price increases have led to slow growth in tilapia supply, and some farmers have switched to other industries. In addition, the increasing constraints on natural resources, especially land and water resources, and the Chinese government's requirements for high-quality aquaculture environments will continue to slow down or even decrease the growth in China's tilapia supply. Thus, China's tilapia industry will undergo transformation and upgrading.

## **Conclusion**

The aquaculture of tilapia in China has proliferated and it has become the world's largest tilapia producer. Tilapia products are mainly supplied to the international market, and there is a high degree of dependence on foreign markets. International orders for tilapia mostly rely on foreign middlemen in transactions, and thus export prices are controlled by foreign intermediaries, and independent export channels are lacking. Chinese tilapia is exported to a diverse range of countries. However, the impact of the US market on Chinese tilapia exports cannot be underestimated. The US is China's most significant target for tilapia export. Thus, the Chinese tilapia industry is highly dependent on the US market, and changes in consumption trends and consumer psychology in the US market will significantly impact this industry.



The demand for tilapia in China has fluctuated dramatically, especially due to the impact of the COVID-19 epidemic and uncertainty in foreign markets. Given its current status, the Chinese tilapia industry must actively develop a healthy farming model to promote its upgrade. A development plan should be formulated based on global demand, and active measures must be taken to achieve coordinated development. International demand, increasing the domestic market by promoting local consumption and breaking the regional and seasonal oversupply caused by information asymmetry should be considered. Improvements are required to tilapia processing technology, especially updating the fresh fish maintenance of the storage technology, allowing tilapia products to generate more foreign exchange value and promoting a balance between supply and demand in the Chinese tilapia industry.

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