

## The development of grain storage technology in China

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### Abstract

This paper describes the present status and developmental trends of grain storage technology in China from the aspects of green grain storage, ecological storage, the harmony of man and nature, market access systems and the developmental trends of the socialized service. The application of controlled atmosphere storage and the ecological storage theory of Chinese characteristics has been established. Information technology and intelligent ventilation technology has been developed for the grain storage industry and grain storage in rural regions has received attention by the governments. The technical regulations of grain and oil storage and other important technical specification standards have been widely advanced for publicity. The paper has also analyzed the problems with phosphine resistance of pests in stored products, serious moisture loss in grain storage and incomplete establishment of economic operation modes of grain storage, as well as partial recognition of green storage technology by markets which presently exist in China. Furthermore, a process to spread development of grain storage technology of China has been proposed.

Keywords: development, grain storage, technology

### 1. Introduction

Under the guidance of ‘China’s grain storage ecosystem theory system’, grain storage concepts are undergoing a profound change. The rapid development of electronic information technology also provides an opportunity for the application and development of grain storage technology, and China’s grain storage technology is developing from the safe storage stage of “no pests, no mildew, no mice and sparrow, no accident” to the “green, eco, intelligence, high efficient” eco-storage stage. In recent years, the application of temperature controlled atmosphere storage technology, low temperature storage technology, information technology, control technology and other new technologies in grain storage has greatly improved the technology of grain storage in China, and made a positive contribution to the energy-saving & emission-reduction and environmental protection.

#### *1.1. Initially establish the theoretical system of China’s grain storage ecosystem*

Mr. Jin Zuxun, one of China’s famous grain storage experts, considers that grain and oil storage research should examine the relationship between grain (main body of storage ecology) and the environment (non-biological & biological environment). During the storage period, different storage conditions, methods and treatment can change the physiological and biochemical features of the grain, the grain quality (process quality, edible quality and breeding quality, etc.), the growth and decline of the harmful and beneficial organisms in the grain mass (grain storage pests, mites, microbes & natural enemies) and the succession change rules. Since the 1990s, Nanjing University of Finance and Economics, Hunan University of Technology, Chengdu Grain Storage Research Institute and other colleges and

scientific units have conducted systematic research under the leadership of Professor Zuxun. Researchers divide our country into seven grain storage eco-regions, and examine suitable grain storage structures in those different regions. Different types of grain warehouses must be equipped with different grain storage technologies, insect and mold prevention technology; the best operational mode for different grain storage and prevention technology, and technical evaluation system are assessed. The newly-formulated national standard of Grain and Oil Storage Technical Specification has fully introduced the concept of eco-storage, the Sinograin also formulated “Grain and Oil Storage Technical Specification in Different Regions” corporate standard to guide the enterprises to store the grain scientifically.

### *1.2. Innovate the research method for the basic theory of low-temperature grain storage*

The influence of different grain storage eco-regions in China on the temperature and humidity of the stored grain and the change rules are researched. The influence of different grain temperature recovery rates on grain storage quality and the effect of low-temperature storage to delay the deterioration of quality are examined. The best optimized mode for low-temperature grain storage based on a systematic method is also proposed, thus laying the theoretical foundation for the promotion and application of low-temperature grain storage technology. In our country; the requirement of low-temperature grain storage technology applied in different grain storage eco-regions and the optimized program for grain storage in corresponding grain storage eco-regions were formulated. Sinograin also works out the temperature- controlling technology standards and adopted temperature control technology in different regions, thus greatly promoting the application and development of low-temperature (temperature control) grain storage technology.

### *1.3. Innovate the basic theory of grain storage ventilation technology*

The grain equilibrium moisture mathematical models and ventilation window theory researched in China are applied for storage. The grain equilibrium moisture mathematical model provides a theoretical foundation to develop the grain analytical system using artificial intelligence. The intelligent grain detection and analytical technology is widely applied in the national grain depots, and it has resulted in significant social and economic benefits.

### *1.4. Establish a main grain equilibrium moisture model in China*

The State Administration of Grain Science Research Institute and Chengdu Grain Storage Research Institute have tested the desorption and adsorption equilibrium moisture of the paddy, wheat, corn and soybean, established the desorption and adsorption equilibrium moisture isotherm equation, thus providing the basic data for China’s grain storage and process.

### *1.5. The investigation of grain storage insects achieves progress*

From 1955 to 2005, China has conducted four national grain storage insect investigations. Among them, the number of insect species in the fourth national grain storage insect investigation in 2004-2005, is the largest, 270 grain storage insect species (including natural enemies) were collected and recorded, including 226 pests and 44 grain storage natural enemy species. The occurrence and development of grain storage insects with potential danger and several important grain storage pests were also analyzed. Chengdu Grain Storage Research Institute has conducted multiple surveys and researches on resistance to phosphine. Results show that phosphine resistance is increasing. The percentage of the resistant insects was resistibility 1.5% before 1988, 5.3% in 1988, 17.4% in 1992, and 28.2% in 2005. For example, the resistance ratios of *Sitophilus oryzae* (L.) has increased 10.7% during the last 8 years.

## **2. A number of advanced and applicable technologies are applied**

### *2.1. Controlled atmosphere grain storage technology is in the international leadership*

China began research on grain preservation technology in the 1980s, fully analyzed the use of carbon dioxide for control, and conducted small-scale pilot tests. In 2001, the first modern facility was built in Mianyang, Sichuan with the capacity of 41.5 million kg. Later, the demonstration project expanded to Jiangsu Nanjiang, Shanghai, Anhui Liu'an, Jiangxi Jiujiang, and others, thus increasing the total capacity of controlled atmosphere grain storage to 0.215 billion kg. Since 2005, with the constant increase in the price of carbon dioxide price and the constant decrease of nitrogen, we began examining the use of nitrogen in combination with temperature, and today we have implemented nitrogen temperature-controlled grain storage technology. The application region extends from the southern high-temperature and high-humidity areas to the central region, and includes paddy, soybean, corn, and wheat. Through constant optimization the cost of nitrogen controlled atmosphere grain storage can be controlled within 0.5 Yuan/ton generally, some grain depots even reduce the cost as low as 0.3 Yuan/ton.

### *2.2. Low-temperature (temperature controlling) grain storage technology is promoted for universal application*

Since 1998, "grain cooling" has been applied as one of the 'four new technologies'. In order to have a better use of our natural low-temperature resource and develop the low-temperature grain storage technology with Chinese characteristics, Chengdu Grain Storage Research Institute cooperated with related units in 2001 to build low-temperature grain warehouses with natural low temperature to store the grain at advanced level in Chengde directly subordinating to Sinograin. Now, the economic benefits of storing grain with natural low temperature is highly valued by the grain storage enterprises in our country, and each region develops components according to the circumstances, such as polyurathamic ceiling technology, dynamic heat insulation technology, ceiling and roofing sprinkler technology. Meanwhile, the smart ventilation technology is constantly improved and the application is promoted. Sinograin proposes the controlling temperature grain storage technical specification, and it has been widely applied.

### *2.3. Grain storage industry fully eliminates methyl bromide*

With the support of UNIDO, China's grain storage industry began eliminating use of methyl bromide, thus promoting the alternatives of 'phosphine under-film circulation fumigation technology' and 'phosphine and carbon dioxide mixed fumigation technology', and established 34 methyl bromide alternative technology equipment to aid warehouse demonstration depots. Some grain warehouses also transformed the alternative technology through self-financing. The task of eliminating methyl bromide in the grain storage industry was completed smoothly and it achieved a remarkable result. Since January 1, 2007, China's grain storage industry has eliminated the use of methyl bromide. In 2013, Chengdu Grain Storage Research Institute destroyed methyl bromide in all warehouses with the support of the Chinese Ministry of Environmental Protection and State Administration of Grain. About 19,926 kg of methyl bromide from 44 units were destroyed, thus completing the task "to eliminate the methyl bromide in China's grain storage industry". The universal application of phosphine re-circulation fumigation technology, with the guidance of effective insecticide concentration and treatment times (CT product), also helped eliminate the use of methyl bromide. The promotion of phosphine under-film circulation fumigation technology reduced the amount of aluminum phosphide used by 80% in the grain and oil warehouse industries.

*2.4. Farm grain storage technology is widely applied; the farmer's grain storage loss is greatly reduced.*

Over 60% of the grain after harvest is stored in rural areas in China. For the rural grain storage condition is poor, the loss rate is higher. A series of household new grain storage equipment suitable for different regions and different grains in China has been developed for different regions. Since 2007, over 5 million farmers have new household grain storage equipment. Meanwhile, rural grain storage scale mathematical models and household grain storage predicted through the regression analysis. Rural resident family net income per capita, peasant family resident population and grain output are the variables of the household grain storage in our country. In order to facilitate the household grain storage knowledge, a rural grain storage expert advisory system has been developed. In order to further determine loss at the farm storage level, a sampling method was formulated for the seven grain storage eco-regions in China. Layered three-stage unequal probability PPS system sampling method and linear random sampling method are applied, the confidence probability of 95% is proposed with by sampling 5969 households from 373 counties. In 2008, State Administration of Grain organized and developed the national farm grain storage loss investigation.

*2.5. Intelligent grain depot construction has been demonstrated and applied*

Applying the modern information technology and IOT technology in the grain storage enterprises can improve grain storage management and is highly emphasized by the grain warehouse enterprises. At present, the main contents of intelligent grain warehouse construction includes management information formatting and operation process automation. It can be divided into a business management system, network auto-office system, grain condition monitoring system, intelligent ventilation system, intelligent controlled atmosphere system, intelligent grain detection system, grain condition measuring remote monitoring platform, etc. specifically. Currently, Sinograin has constructed a number of intelligent grain warehouse demonstrations.

### **3. China's grain storage technology development prospect**

Through upgrading the traditional grain storage technology, the "green, ecology, harmony" of grain storage technology can be realized, and "three-high of high quality, high nutrition, high efficiency" and "three-low of low loss, low pollution and low cost" objectives of grain storage can be achieved. The grain green storage technology system combining low temperature and controlled atmosphere will be established. The traditional grain storage operation and management mode will be improved with information technology, smart technology and IOT technology. The grain storage technology shall be regionalized, and the grain storage economic operation mode at different grain storage eco-region shall be established. In addition, the storage quality will be improved for increased market acceptance and guarantees.