Review and prospect of grain storage technology applied in Hubei, China

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Abstract
Great progress has been made in China since its foundation. This paper introduces 10 applied techniques used in safety grain storage. They are: grain storage with protectants, 'double low' storage, ventilation storage, low temperature storage, grain storage in open air, grain drying, quality inspection and control, grain fumigation, computer application and grain storage in countryside. The paper probes into the trend of grain storage techniques in China in future and puts forward that: cold storage and ventilation will be widely developed; there is a new breakthrough in rice quality, granary mechanization is important for building national grain reserve depots; application of computer will be rapidly developed.

Introduction
Since the foundation of the People's Republic of China, great progress has been made in grain storage technology, especially in the last 20 years, the level of scientific grain storage has been raised. At present, there are a large number of workers who master grain storage technique; scientific and technical content of grain preservation is continuously increasing. 'Four Free' grain depots (pests free, deterioration free, birds and rodents free, accidents free) have been set up in the whole country, the loss of stored grain is obviously decreased. The loss rate of rational grain reserve depot is below 0.2%, technological level of grain preservation has been greatly improved. The paper reviewed the development of grain storage techniques in China, especially in Hubei province, and made prospect for the development of grain storage technique in 21 century.

Reviews of Grain Storage Techniques in the Last 50 Years

Through reviewing developing history of grain storage techniques in Hubei province, we can find that there is a new start every ten years. Experiments on paddy long-term storage were done, the change of the law of 'three temperature and three humidity' was mastered in the 50's. Cereal protectants were thoroughly studied, solid foundation on spreading protectants was laid in the 60's. 'Double low' (low oxygen, low dosage) grain storage technique was studied and spread in the 70's. Drying and Ventilation techniques were developed and mechanical ventilation was popularized, at the same time, stored-pests investigation of wide scope was done in Hubei province in the 80's. In the 90's, computers are used in grain depots and microelectronic technique is applied in dynamic management of grain reserve. Besides, pest development law of stored-grain in open air and integrated control technique are studied. All facts show that scientific techniques have extended the development of grain storage. The developments of grain storage techniques during the last 50 years are as follows:

The use of grain protectants
Hubei province is one of the provinces that firstly use protectants for grain storage. Lindane powder was used in the 50's. Malathion (purity over 95%) was primarily used in the 60's. Deltamethrin and Fenitrothion have been used since the 80's. Chlopyrifos methyl, Pirimiphos-methyl and Valexon are applied in small experiments. Mixed Malathion with grain in Hubei had gone through three stages: experiments in the 60's, spread in the 70's, development in the 80's. 50 billion kilograms grain is dealt by Malathion in the whole province, many fumigation expenses are saved and stored-grain safety is assured. Because Malathion is used for a long time and pests develop serious resistance, new protectants are needed to take place of Malathion. Mixture of malathion and deltamethrin or mixture of deltamethrin and fenitrothion are used in Hubei province. There are two kinds of common mixed drugs: (1) Mixture of malathion and deltamethrin. Namely, malathion and deltamethrin mixed with pottery clay or hull bran powder. The powder contents 1% malathion, 0.02% deltamethrin, every kilogram powder is mixed with 1000kg raw grain, content of valid drug on grain surface is 10pp malathion and 0.2ppm deltamethrin. (2) Mixture of deltamethrin and fenitrothion. Contents of valid drug on grain surface are 7ppm fenitrothion and 0.2ppm deltamethrin. These two kinds of drugs can maintain stored-grain free of pests in one year.
they are specially effective to Rhizopertha dominica

‘Double low’ grain storage technique

‘Double low’ (low oxygen, low phosphine dosage) is developed on the basis of oxygen-free storage. Because there are some problems of artight materials, natural oxygen-free storage can not kill pests and must apply low dosage aluminum phosphate tablets. The main points of ‘Double low’ are the technical improvement of the depot, the improvement of the air-tightness of films, timely sealing grain with films, rationally applying low dosage. Sealing quality of the films should meet the standard: grain surface looks like glass, no folds, straight line along the wall and the film edges should be buried for sealing. ‘Double low’ bans, of which doors and windows should be double layers and sealed by films, should have working chamber and protective door. A group of personnel needs to be trained to know how to seal the film effectively. ‘Double low’ grain storage technique has been popularized in the whole country during the past 20 years. There are over 100 billion kilograms grain stored by this method in Hubei Province.

Ventilation technique of grain storage

Experiments on grain storage by mechanical draft was at the Grain Depot No.2 of Wuhan City in the 50’s, however, this technique was not applied until the 80’s. On the trial in Puxi Grain Bureau basis, mechanical draft grain storage was spread in Hubei province in 1984. The trial results show that mechanical draft grain storage has various advantages such as prolonging storage period, maintaining grain quality, reducing loss due to insects and molds. Mechanical draft was popularized in Hubei province from 1984 to 1987, there are about 60% grain stored by mechanical draft. There are three modes of mechanical draft: geosyncline type, air-stock box type and pipe layout type. The three kinds ventilation basins are efficient to lower temperature of stored-grain. Geosyncline ventilation is more effective in lowering moisture, the moisture of short-grain non-glutinous paddy stored by this method can be lowered by 2 - 3%. Hubei Grain Bureau issued geosyncline drawing designed by Jingzhou Grain Bureau in 1986 and put forward that newly built grain depot must be laid ventilation geosyncline.

Low temperature technique

Low temperature by refrigeration has been applied since the 80’s in Hubei province. Horizontal warehouse of Soviet Union origin was remade into a cold warehouse in Grain Depot No.2 of Wuhan City in 1980. The warehouse uses pearl rock as heat insulation material, uses refrigerator to lower temperature. Temperature inside warehouse maintains at 15°C, the rice (glutinous rice and long-grain non-glutinous rice), which is stored one year in cold warehouse keeps fresh, the colour, odour and taste of food made of this rice is normal, however, quality of rice by conventional storage is aging. Effect of refrigerator cold storage is good, but power consumption is too much, therefore, this method is not spread.

To probe into economic and effective cold storage technique, Storage and Transportation Company of Huangshi City did experiments on using window air conditioners to store rice, peanut, and sesame. The result is successful. In 1986, cooperative group of urban temperature-control storage with air conditioner of Hubei province held a discussion in Huangshi, it promoted technological development of urban low temperature storage for rice. The technique was spread over Wuhan, Yichang, Shashi, Shiyen and so on.

Natural cold storage is a main part of low temperature. During the winter, open windows and doors of warehouses can let cold airs flow through the grain surface and cool grain layer by layer. Turn over grain and dig up gaps can enhance ventilation effect. In Hubei province, grain temperature can be lowered to below 8°C in plain area or below 5°C in mountain area. Hubei province proposed temperature control standard of stored-grain in the winter in 1990, it is required that grain temperature inside depots should be controlled within 20°C. In 1997, they revised the standard, namely, grain temperature inside depot cannot be over 25°C and temperature of grain in open air can not be over 28°C in summer and autumn. Grain temperature inside depot can not be over 18°C and temperature of grain in open air can not be over 15°C in spring and winter.

Technique of stored-grain in open air

Storing grain in open air began from the 50’s, Hubei Grain Bureau drew up ‘Operation regulation of fumigation of grain stored in open air’ in July, 1983, which efficiently prevent fire from happening. Hubei province spread mouse-proof goods yard and raised quality of grain stored in open air in 1984. Hubei Grain Bureau drew up ‘Management standard of grain stored in open air in Hubei province’ in 1990, grain stored in open air was standardized and systematized. On-the-spot meeting of national grain storage was held in Jingzhou, Hubei province, and experience of storing grain in the open air was spread in Hubei province in May 1991. Characteristics of stored-grain technique in open air in Hubei are: (1) Capacity of stack is large. General capacity of stack is 250,000 kilograms grain, and that of the largest grain bulk is 1,000,000 kilograms. (2) Mouse-proof function is strong. Platform is 0.7 meters above ground level, the surface goes beyond platform 0.15 meters, so mouse can not climb. (3) There are diversities of types of storage. There are fixed platform goods yard, prefabricated overhead goods yard, depot-type goods yard, pool-type goods yard and brick overhead goods yard. (4) Management is convenient. A lot of methods were adopted, such as
According to the materials used, dryer can be divided into two categories: Grain drying technique and automatic control of the grain temperature. The former is quite effective, namely, 'prevent dew, reduce grain piled as ladder, ventilation, protectants mixed with grain'. This technique involves small-scale dryer and middle-sized dryer. According to_width, dryer can be divided into small-scale dryer and middle-sized dryer. Middle-sized dryer is 3.8 meters long, 0.42 meters wide, and output is 7.5 ton per hour. Advantages of fluidized-bed dryer are: simple structure, less materials, easy production, convenient repair and suitable for grain depot in countryside. The power which can be used is coal and paddy hull, paddy hull can be consumed 50 - 70 kilograms every hour. However, dryers are not brought into play and most of dryers are set aside in Hubei province.

**Grain drying technique**

Experiments on grain drying by dryer were done in Hubei province in the 50's. In 1984, there were two grain machine plants in Xianning and Tianmen, Hubei province that produced fluidized-bed dryer. There are 100 fluidized-bed drying shops and 100 sets small-scale mobile fluidized-bed dryer built in the whole province within 5 years. Grain drying by fluidized-bed dryer is a successful technique. According to the materials used, dryer can be divided into steel dryer and brick dryer. According to_width, dryer can be divided into small-scale dryer and middle-sized dryer. Middle-sized dryer is 3.8 meters long, 0.42 meters wide, and output is 7.5 ton per hour. Advantages of fluidized-bed dryer are: simple structure, less materials, easy production, convenient repair and suitable for grain depot in countryside. The power which can be used is coal and paddy hull, paddy hull can be consumed 50 - 70 kilograms every hour. However, dryers are not brought into play and most of dryers are set aside in Hubei province.

**Technique of quality inspection**

Quality inspection of stored-grain is important. The required reserve period (wheat, 5 years; paddy, 3 years and corn, 2 years) is not scientific. If temperature is controlled and grains are stored under 15 - 20°C cold granary, grain preservation time can be prolonged. The key to the problem is to find out indexes that can be used to weigh up deterioration degree.

Paddy of long-term storage had been studied in Hubei in the 50's. The results showed fatty acid value can be used as an efficient index for forecasting storage properties, reducing sugar value and salt-soluble protein value can predict grain deterioration, too. According to 'Control indexes and determination of grain storage quality', which is set by Chengdu Grain Storage Scientific Research Institute of the Ministry of Internal Trade, experiments on paddy storage quality change were done by Wuhan Grain Depot No. 2 from 1983 to 1985. It proved that germination percentage, viscosity and fatty acid value are important indices for weighing up paddy aging and deterioration. Germination percentage, viscosity and fatty acid value should be regularly determined during paddy storage so that decision can be made whether the paddy could still be stored safely.

**Technique of fumigation**

Technique of grain fumigation develops rapidly in Hubei province. Main fumigant was Chloropicrin, the second was ethylene dichloride and methyl bromide, and hydrocyanic acid was used in grain processing plants in the 50's. Tablet of aluminum phosphide has been used since the 70's, it is mainly used at present. Much research work on applied technique of fumigants was done in Hubei province. Researches on control of Bruchus pisorum by chloropicrin was done in Xiangyang and Luotian early in the 60's. 'Four rapid' measure (raid harvest, rapid thresh, rapid sunning, rapid management) was put forward, and Bruchues pisorum could be killed before it became the fourth-instar larvae. Applied researches on burning preparation of calcium phosphate and adding zinc phosphate into acid were carried out in the 70's. It solved the problem of lacking fumigants. In view of safety, Hubei Grain Bureau set 'Operation rules of fumigating stored-insect by zinc phosphate' in April 1975.

Applicator outside of the warehouse and circulative fumigation were studied in the 80's. Applicators outside of the warehouse are carried batch process in Tianmen Grain Machine Plant. Circulative fumigation is studied in Jingmen and Xiaogan. The technique of aluminum phosphide circulative fumigation together with ventilation through geosyncline can reduce dosage, increase effectiveness, so it is spread and applied.

**Applied technique of computer**

Programming calculators were tried out to purchase grains early in the 80's in Hubei province, the calculator is TI-59 type, and is very useful. Computers are used at grain depot in the late 80's. At present, computers at grain depots have the following applications: (1) Grain condition testing. It is popularly used to remote temperature testing (2) Equipment control. It is used for automatic control of mechanic draft and automatic weighing. (3) Business management. Computers are used to synthesize various report forms, it brings into play efficient action in account management, storage and transport management, grain reserve management, personnel files management and administration. Besides, computer management systems and computer expert systems are studied, but it is not used in practice yet.

**Grain storage technique in countryside**

Attention has been paid to the grains stored in the rural areas in our country. Grain department at all levels preserve national grains, at the same time positively help countryside to develop grain preservation. Grain stored in countryside has gone through three phases, namely, 'Four Free' grain depots were developed in countryside in the 60's. Grain department put forward construction of large depots...
Prospect of Grain Storage Technique

Since the foundation of the People's Republic of China, great progress has been made in grain storage technique. However, compared with developed countries, great difference still exists especially on mechanized equipment. The developing trend of grain storage technique in our country is that low temperature and ventilation will be widely used; there will be a new breakthrough in rice quality; granary mechanization will be important in national grain reserve depots; application of computers will be rapidly developed.

Low temperature and ventilation

Cold storage means grain temperature controlled below 15°C all the year round. Quasi-low temperature storage is grain temperature controlled below 20°C. According to national condition, we think that cold storage should accomplish: (1) Improve technique of finished product of grain stored in cities by air conditioner. (2) Apply refrigeration technique to get low temperature, remake heat-insular horizontal warehouses (3) Enhance researches on mechanical draft, lower grain temperature by ventilation. Ventilation with low temperature will open a new situation in grain storage.

New breakthrough of rice quality

The main crop in China is rice. With the rising living standard, fine foods are needed, new breakthrough of rice quality is necessary. In view of experiences of Thailand and India, the aim of rice quality breakthrough is (1) Produce fine variety (2) Process good quality. (3) Set up standard of high quality rice.

Mechanization of national grain reserve depot

In view of experiences of granary mechanization in the past, when we build granary in our country, we must pay attention to granary mechanization; moreover, we should rationally equip granary machine according to granary characteristics. Compared with other countries, we have a large number of horizontal warehouses. To ensure horizontal warehouses mechanization, work tower must be built in the center of granary, collocates bulks lorries and transport equipment. In the future, our country should build several demonstration mechanized reserve depots, attention must be paid to the mechanization of bulk transport.

New development of computer application

There are many computers used in national grain reserve depots, but the effect is not good, and an application of computer in granary depot needs to be further exploited. We need to equip grain enterprises with modern technique, improve working environment, and raise working efficiency. We should exploit computer system and train more personnel. We believe that grain loss can be minimized greatly if computers can give full play in grain storage.

References