Effects of temperature on rice quality and mass loss

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Abstract

After two-years storage of *indiaca* rice withe 13.5% moisture content and *japonica* rice with 14.3% moisture content at 10, 20, 25, 30, 35, and 40℃, the results from the determination of the fatty acid, water soluble acidity, viscosity and germination rate demonstrated that the higher the temperature, the faster the changes of deterioration, the faster the decline of viability, and the shorter the safe storage period Fatty acid value was closely correlated with the deterioration of grain, but it can not be used to monitor the change of quality inlong term storage The movement viscosity of rice is an useful index for monitoring changes of quality in stored rice or paddy. The regressive grading value is an important index for judging the quality ofstored rice When regresive grading value is lower than 65, stored rice or paddy may start to deteriorate After being stored at different temperature for two years, the mass loss rate of *indiaca* or *japonica* paddy was in the range from 0.14% to 0.50% (dry basis). In the range from 10℃ to 30℃, the higher the temperature, the higher the mass loss rate.

Introduction

Post-harvest loss of grain is a worldwide problem. The investigation report of FAO (Food and Agriculture Organization of the United Nations) shows: the grain loss in the world is 3% caused by fungi and 5% caused by insects every year. In 1975, the 7th UNGA(United Nation General Assembly) Special Meeting advanced that the grain loss of the member countries should decrease 50% in 1985. In China, the storage policy of grain and oil take prevention and integrated pest management as the keys. At the same time, we also launch the 'FOUR NO' grain storage [Insects-free, Fungi (mould and others)-free, Rodents-and Birds-free, and Accidents (fire, water damage etc)-free] activities. So the grain loss during storage is a little In order to accurately grasp the mass loss rate during storage at different temperatures and provide the basis for working out the natural loss standards of stored rice at many different sites in China, we perform this project.

Experimental Materials and Methods

Experimental grain and storage appliance

The experimental grain is the new-harvested *indiaca* paddy produced in Chengdu and the new-harvested *japonica* paddy produced in XinXiang, Henan Province. They respectively mix up, and divide into 12 groups with 20 kilogram a group. All of samples were put them into plastic bags. Then these plastic bags were put into the ordered wood boxes Every two wood boxes put into a thermostat.

Determination methods of quality parameters

We sampled test samples every 3 months until 24th month, the following quality parameters are determined:

Moisture content: Whole grain, reached constant weight at 115℃.

Fatty acid value: KOH titration. According to the Chinese National Standard 5510-85.

Water Soluble acidity: KOH titration According to the Chinese National Standard 5517-85.

Viscosity: Measured by capillary viscosimeter. According to the Chinese National Standard 5516-85.

Germination rate: According to the Chinese National Standard 5520-85

Mass loss rate: Measured by burying sacks, then weighing the grain in the sack to calculate the mass loss rate. After cleaning up and sifting the experimental grain, the moisture content was measured. A balance, which minimum readable value is 0.0001 gram, was used to fetch about 150 graim of grain each of the sample. Samples were put into a serial of ordered small sacks, then bury them into the grain bulk separately. After storage, we fetched out the small sacks and accurately weighed the grain weight in the sacks and measured their moisture content. From these data, we calculated the mass loss rate through the weight decline of dry grain matter in the sack as below.

$$L(\%)=[G_1(1-W_1)-G_2(1-W_2)]/G_1(1-W_1)\times 100\%$$

Where: L = mass loss rate (dry-basis);

G_1 = The original grain weight in the sack(g);

G_2 = The grain weight in the sack after storage(g);

W_1 = The original grain moisture content in the sack (%);

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W_2 = The grain moisture content in the sack after storage(%).

Experimental Results and Discussion

Fatty acid

Fig 1 and Fig. 2 respectively represent the changes of fatty acid values of *indiaca* paddy and *japonica* paddy stored at different temperatures. These two pictures show that the longer the storage period and the faster the increase of temperature, the higher the fatty acid values. The fatty acid values of *indiaca* paddy and *japonica* paddy increased rapidly when they were stored at 35℃ and 40℃. The fatty acid values increased more slowly when *indiaca* paddy was stored below 30℃ or *japonica* paddy was stored below 25℃.

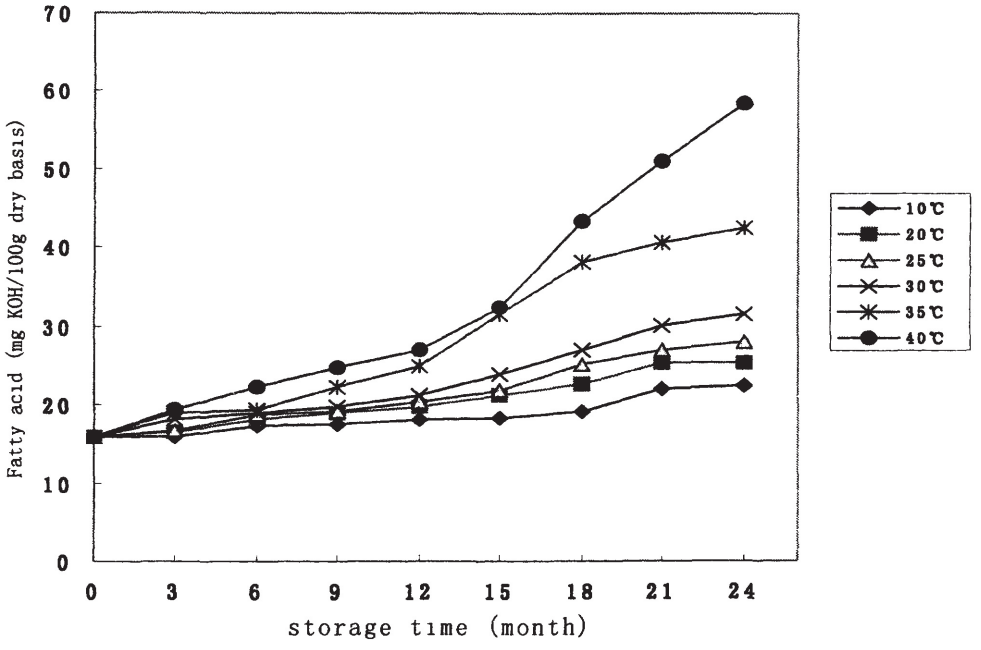

Fig. 1. Fatty acid value of *Indiaca* paddy stored at different temperatures

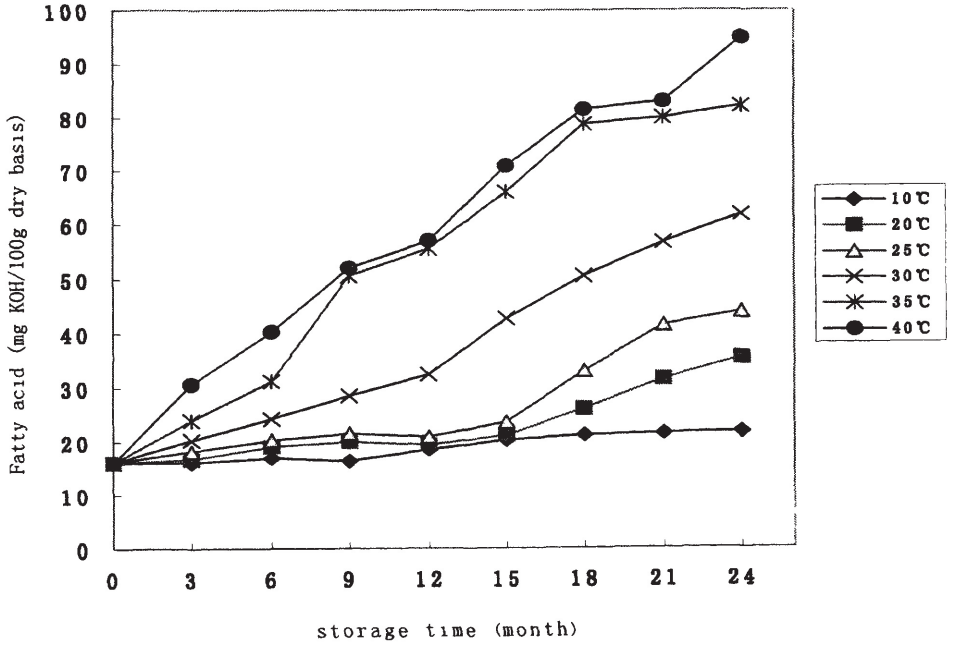

Fig. 2. Fatty acid value of *Japonica* paddy stored at different temperatures.

The fatty acid value is used to inspect the amount of free fatty acid in the rice. Because of the enzymatic and non-enzymatic hydrolysis to the lipid in the rice, the fatty acid value increases. The longer the storage time, the higher the fatty acid value, accompanied with the prolongation of storage period, the fatty acid value increased remarkably at the higher temperature

The fatty acid value is closely related to the deterioration f the grain. It can express the deterioration extent of the rice during storage, so that it is an important index. It indicates the deterioration in the first stage during storage Fatty acids can be hydrolyzed continuously, and lead to the decrease of the fatty acid value

Water soluble acidity

Fig. 3 and Fig. 4 respectively represent the changes of water soluble acidity of *indiaca* padyy and *japonica* paddy stored at differnet temperatures. the figures show that the increase of water soluble acidity was accompanied with the prolongation of the storage period The higher the temperature, the faster the increase. Increase of water soluble acidity was the fastest at 40℃, but it was slower below 25℃.

Water soluble acidity of grain represents the total amount of water soluble acidic materials in the grain. the amount of acidic materials in the normal-quality grain is very little. If the temperature is too high, the amount of acidic materials in grain will increase quickly The abrupt increase in water soluble acidity is a signal of the deterioration of the paddy. Changes in water soluble acidity of the stored grain are very complicated Water soluble acidity of grain decreases when the deterioration of the grain is serious, so that we can not judge the grain quality only by the value of water soluble acidity

Viscosity

Fig 5 and Fig. 6 respectively show the changes of movement viscosity of *indiaca* paddy and *japonica* paddy stored at different temperatures. The figures show that decrease of viscosity was accompanied with the prolongation of the storage period, when paddy was stored at different temperatures. The higher the temperature, the faster the decrease Especially, when paddy was stored above 35℃ over half a year, viscosity of paddy decreased rapidly The viscosity of cleaned paddy is determined by the micella system, which is made up of its micella particles, and mainly determined by the starch. The viscosity of micella system formed by amylopectin is larger than that by amylose. When they are solved by water, the viscosity decreases. The movement viscosity of cleaned rice was measured in our experiment. We can appreciate the viscosity of cleaned rice Viscosity can be used as one of parameters to study the quality changes of the cleaned rice.

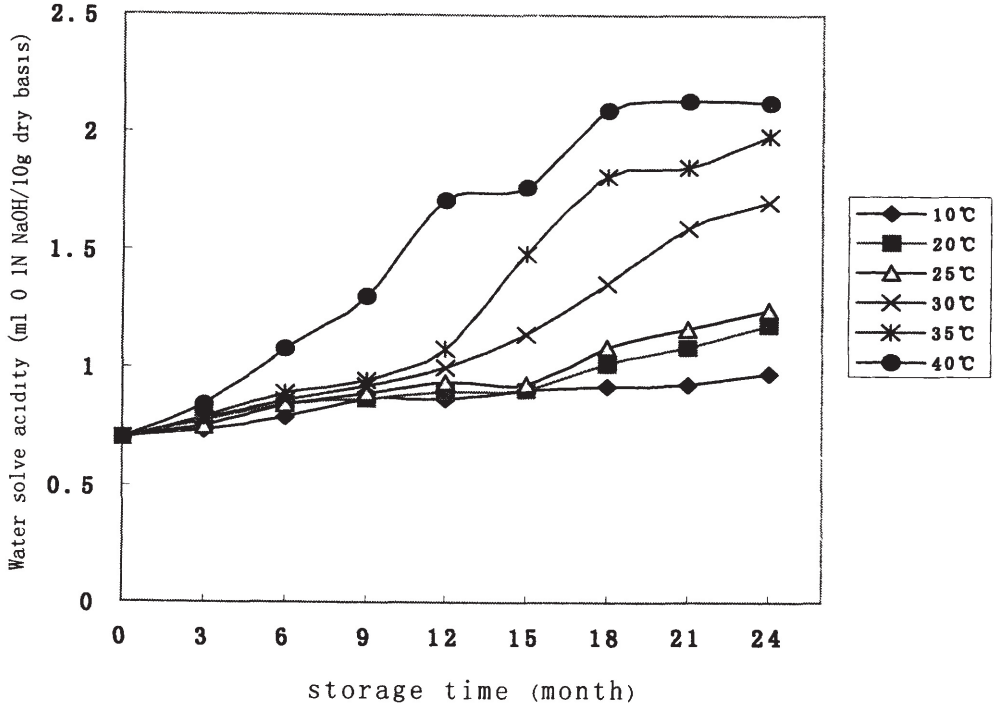

Fig. 3. Water soluble acidity of *Indiaca* paddy stored at different temperature

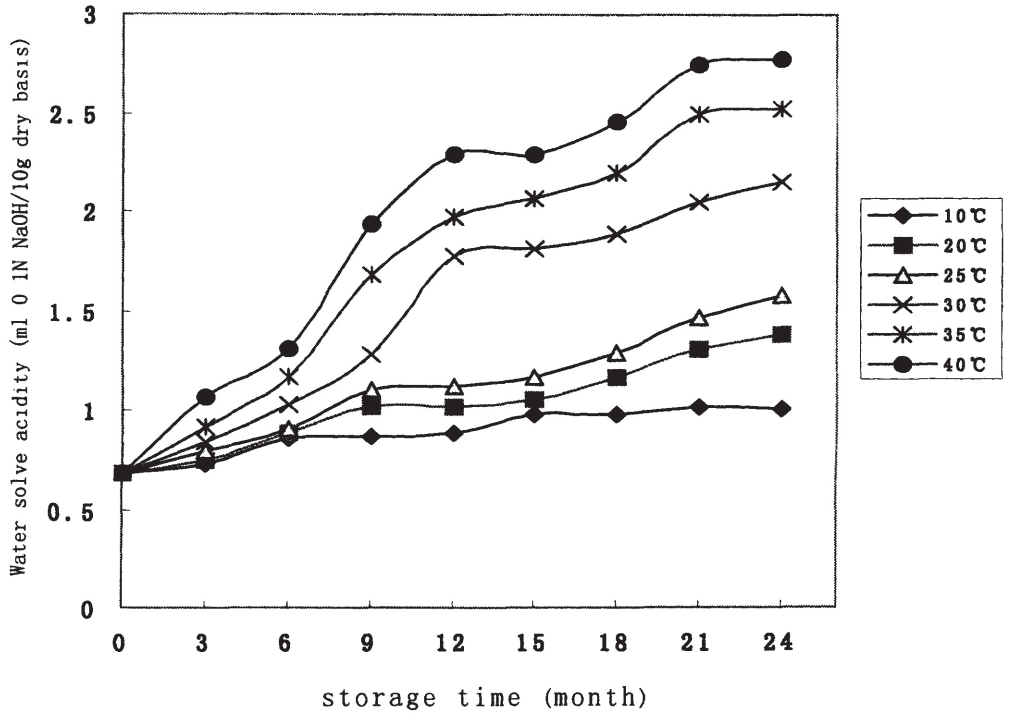

Fig. 4. Water slove acidity of *Japonica* paddy stored at different temperature.

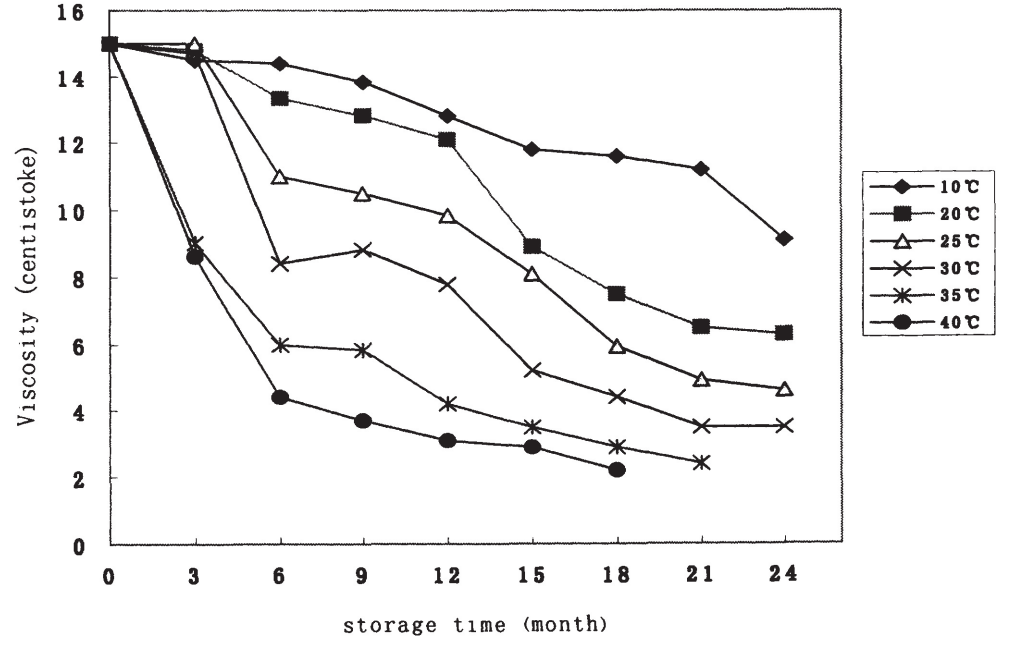

Fig. 5. Viscosity of *Indiaca* paddy stored at different temperature.

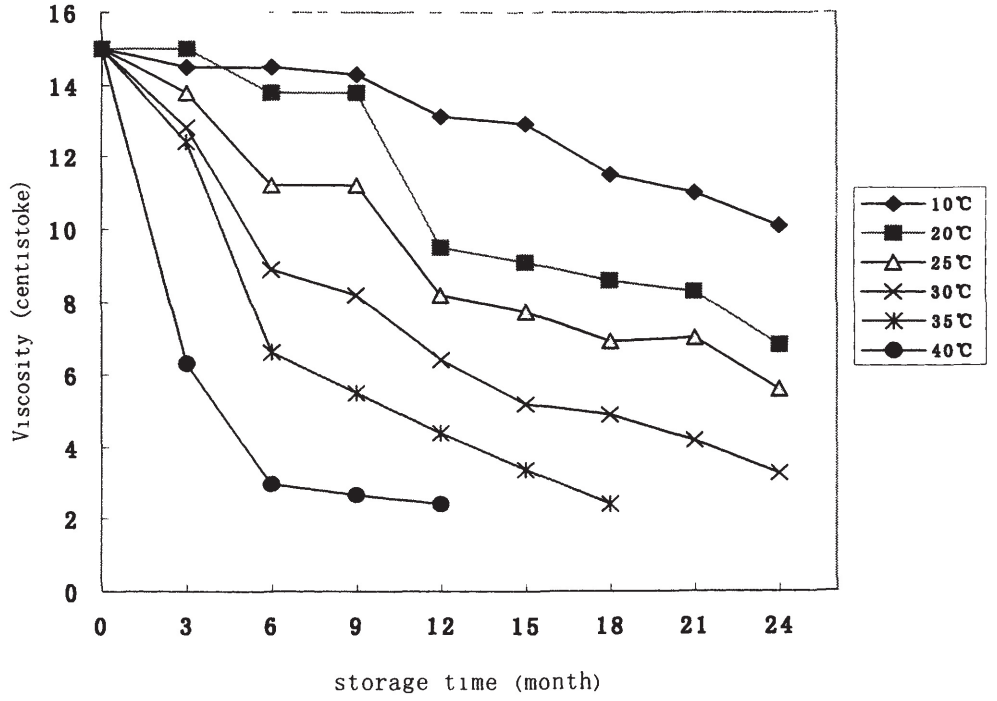

Fig. 6. Viscosity of *Japonica* paddy stored at different temperature

Germination rate

Fig. 7 and Fig. 8 respectively represent the changes in germination rate of *indiaca* padyy and *japonica* paddy stored at different temperatures The figures showed that the higher the temperature, the faster the loss of germination rate. After being stored at 10℃ for 2 years, the germnation rate of paddy hardly decreased; but if the storage temperature is higher than 30℃, the germination rate of paddy will decrease rapidly

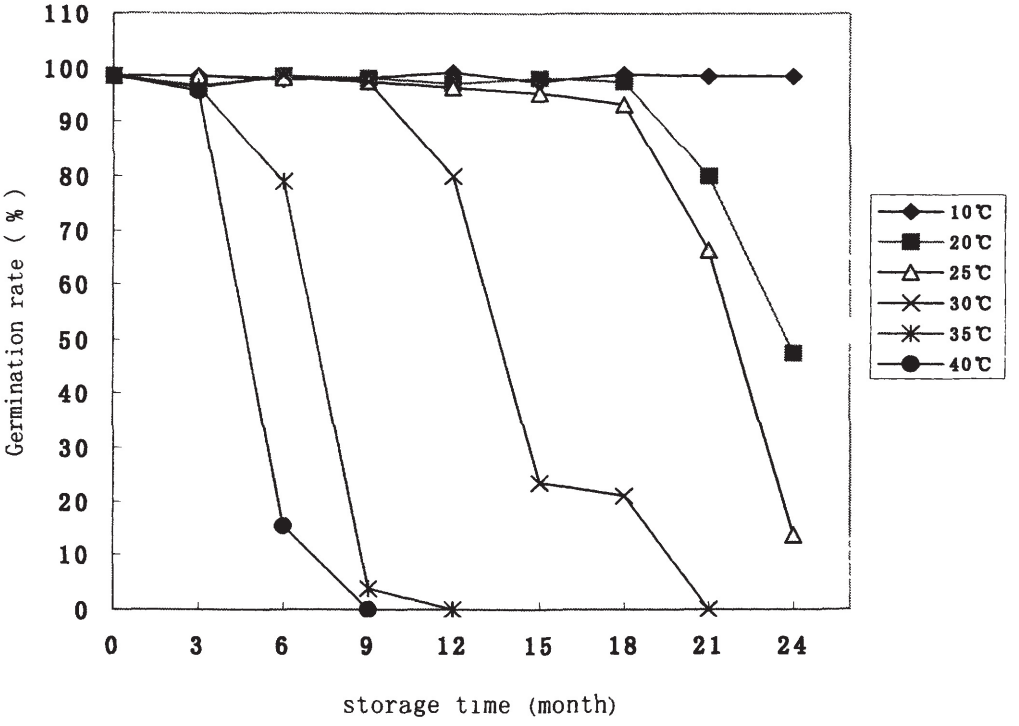

Fig. 7. Germination rate of *Indiaca* paddy stored at different temperature

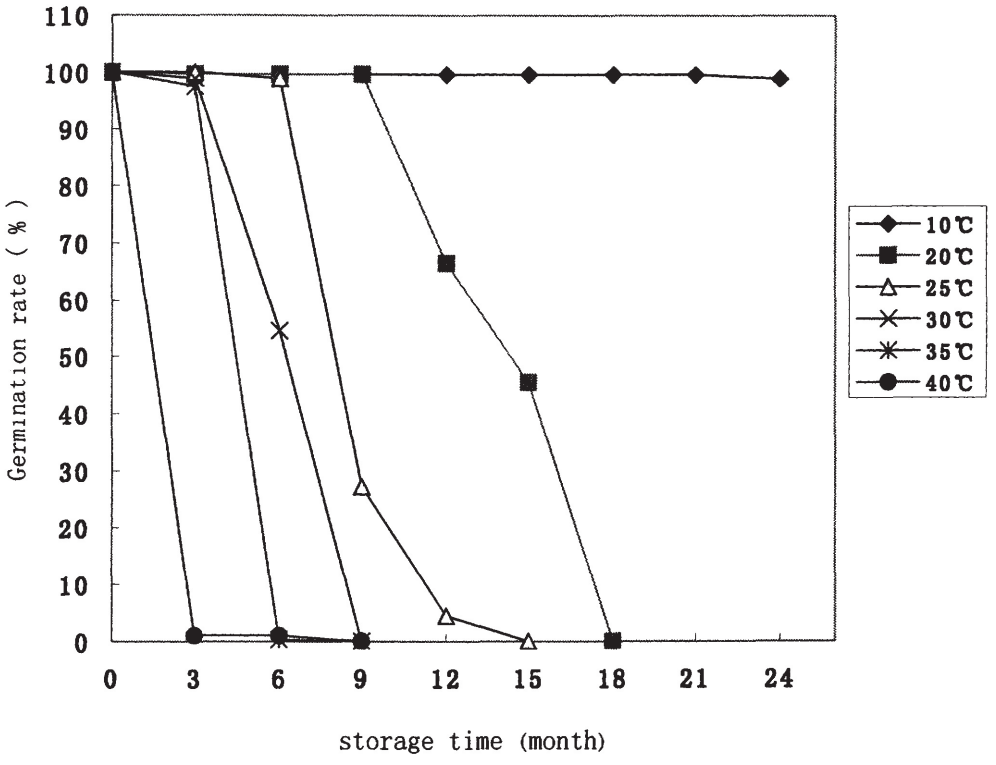

Fig.8. Germination rate of *Japonica* paddy stored at different temperature

Germination rate is used to measure the germination potential of the paddy. High germination rate means the amount of the dead seeds is small. The paddy, which will be used as seed, must have high germination potential. If the drying temperature applied to post-harvest paddy is too high and the storage conditions are unfit, the germination potential of paddy will be affected. Accompanied with the prolongation of storage period, germination rate of paddy decreases. Germination rate is also one of the important indexes which are uses to measure the paddy quality. The lower the germination rate, the lower the vitality of paddy and the more serious the staleness of paddy.

Regressive grading value and safe storage periods

'Technical Standards of Rice and Oil Storage', which is issued by Chinese Internal Trade Ministry, regulates that the regressive grading value of *indiaca* padyy and *japonica* paddy are calculated by the following formula:

$Y_{indiaca\ rice} = 65.7 + 0.07 \times$ Germination Rate $- 0.25$ Fatty acid value $+ 1.70$ Viscosity

$Y_{japonica\ rice} = 86.3 + 0.005 \times$ Germination Rate $- 0.61 \times$ Fatty acid valu

Fig. 9 and Fig. 10 respectively represent the changes of the regressive grading value of *indiaca* paddy and *japonica* paddy stored at different temperatures. Figures show that the higher the temperature, the faster the decrease of the regressive grading value. Especially, when paddy were stored at 35℃ or 40℃, the regressive grading value decreased rapidly.

'Technical Standards of Rice and Oil Storage' regulates: that the regressive grading values (*indiaca* and *japonica* rice) should be higher than 65, fatty acid value is lower than 25mg KOH/100g (dry basis) and the viscosity of *indiaca* rice is higher than 3 centistoke for normal rice. The regressive grading value is lower than 65, it means that rice begins to deteriorate and is not suitable to be stored. If the regressive grading value is higher than 65, the fatty acid is higher than 25mg KOH/100g (dry basis) and the viscosity of *indiaca* rice is lower than 3 centistoke, rice is also not suitable to long-tern storage. According to the regulations mentioned above, when the safe storage period of the *indiaca* rice and *japonica* rice at different temperatures is set, the regressive grading values should be the main factors, but we also have to think about the fatty acid value and the viscosity of the *indiaca* fice.

Fig. 11 and Fig. 12 respectively represent the safe storage period of *indiaca* paddy and *japonica* padyy stored at differnet temperatures. Figures show that the lower the temperature, the longer the safe storage period. When padyy are stored at 10℃, it will be stored safely for more than 2 years.

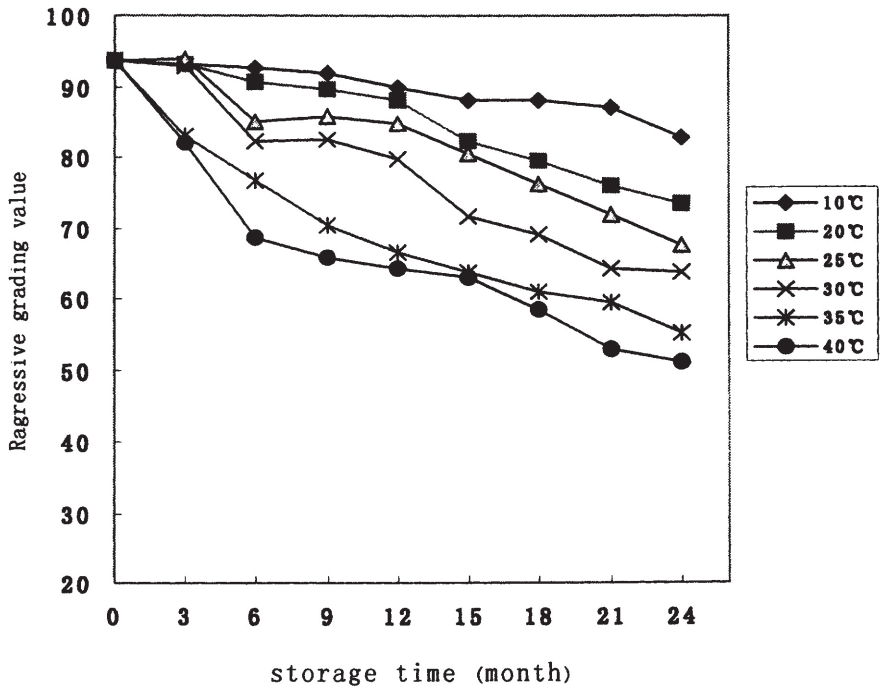

Fig. 9. Regressive grading value of *Induca* paddy stored at different temperature.

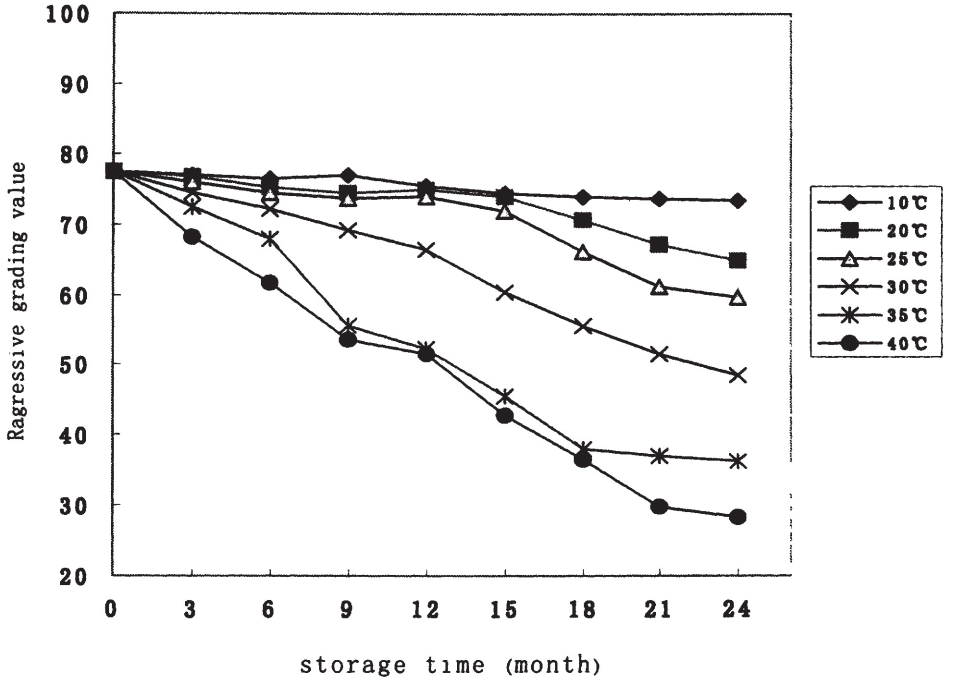

Fig. 10. Regressive grading value of *Japonica* paddy stored at different temperature.

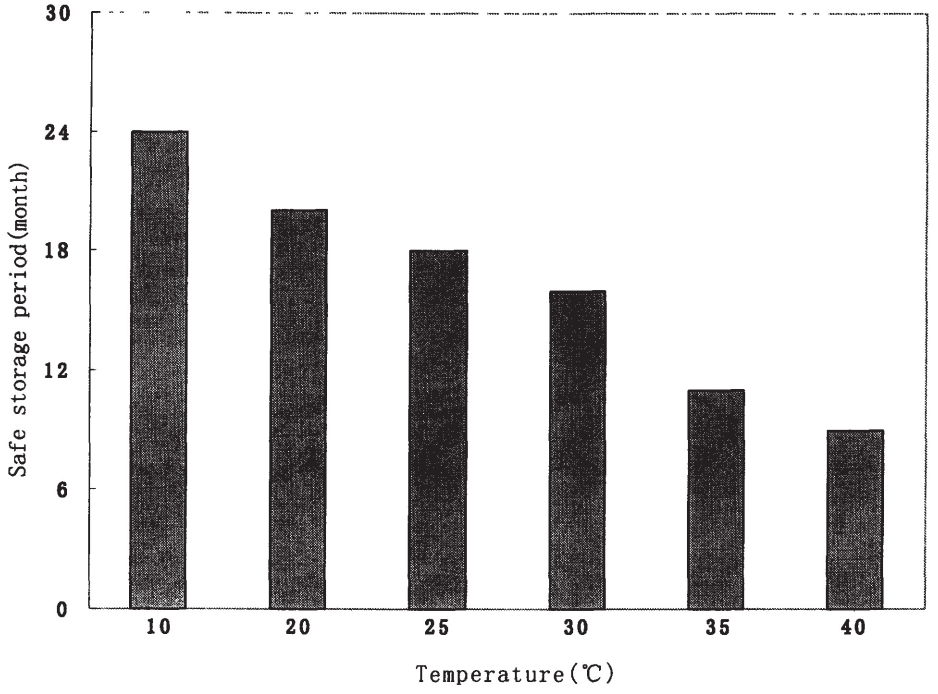

Fig.11. Safe storage period of *Indiaca* paddy at different temperature

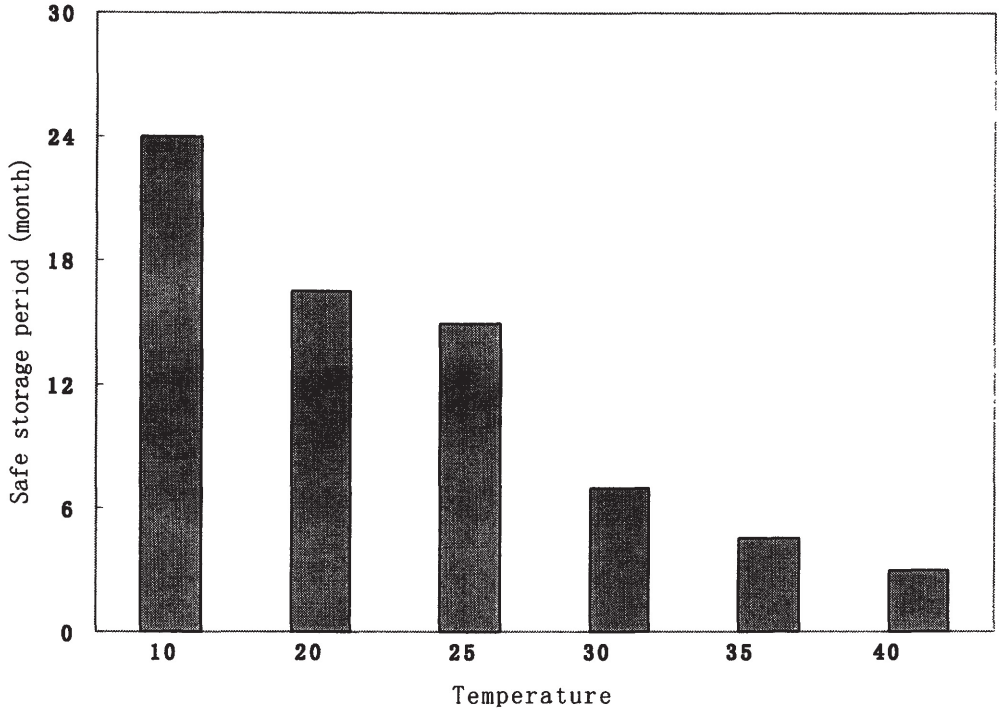

Fig.12. Safe storage period of *Japonica* paddy at different temperature

Mass loss during storage

The loss of rice is mainly caused by the metabolism of the cells in seed and by the activities of organisms and respiration of the microbes, which depletes the nutrition in the rice when rice is stored with little insects and fungi. At the safe moisture content, this depletion is small. But there is no method to accurately measure this depletion at present. The method used in our experiment was that sacks were buried into grain stacks and balanced weight of samples

to measure the mass loss of indiaca paddy and jeponica paddy before and after they are stored at different temperatures for 24 months. Results are shown in Table 1.

Table 1. shows that when the *indiaca* paddy was stored at 10℃ and 30℃, the higher the temperatures, the higher the mass loss rate The mass loss rates at 35℃ and 40℃ were lower than that at 30℃ When *japonica* paddy was stored at between 10℃ and 35℃, the higher the temperature, the higher the mass loss rate The mass loss rate at 40℃ was also lower than at 35℃ The higher mass loss mentioned above are due to that the temperature is high, the metabolism of cells and the organisms is drastically, and the microbiological respiration intensity is great. On the other hand, after being stored some months at high temperature, the vitality of paddy decreased, the respiratory intensity and the mass loss also decreased

Table 1. The mass loss rate of paddy stored at different temperature for 2 years (%, dry basis).

Temperature(℃)	10	20	25	30	35	40
indiaca paddy	0.17	0.37	0.43	0.50	0.47	0.43
japonica paddy	0.14	0.28	0.34	0.39	0.40	0.34

Conclusions

The experiments mentioned above show that, storage temperature is closely related to the changes in quality and mass loss of paddy The higher the temperature, the faster the deterioration, the faster the decline of vitality and the shorter the safe storage period When the temperature of paddy was lower than 25℃, the changes in quality were slow, and when the storage temperature of paddy was in the range of 35℃ and 40℃, the paddy deteriorated quickly. When paddy was stored at different temperature in the range of 10℃ and 30℃ for two years, the higher the temperature, the higher the mass loss. Therefore, in the high temperature season, all kinds of methods must be used to drop the paddy temperature as much as possible and to reduce the loss of the paddy quality and quantity

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