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The impact of two drying methods on the quality of high-moisture rice

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Abstract

In this experiment, freshly harvested rice was dried by natural and mechanical methods. For natural drying, paddy rice was spread on a cement floor under a shelter at a thickness of 4cm, and it was turned twice a day. At a temperature of 19.3°C and a relative humidity of 58.8%, a total of 28 days was needed to reduce the water content from 23.11 to 14.38%. For mechanical drying, the Guwang 5HXG-15B circulating dryer was used, drying temperature was set to 42°C, and it took a total of 5 hours to reduce the water content from 23.1 to 11.8%. The changes in spore count, fatty acid value, germination rate, waist burst rate, whole polished rice rate, and taste value of rice mold after drying were studied. The results showed that compared with mechanical drying, the drying rate of air-dried rice was slower, and the number of mold spores increased from 0.65×10^5/g to 3.05×10^5/g, a 3.7 times increase. The number of mold spores in dried rice was not significant. Dried rice fatty acid value of 25.1mg/100g for natural drying was higher than the value of 19.9mg/100g for mechanical drying. High temperature affected rice seed vigor: mechanically dried rice germination rate was 58.0%, far lower than the 87.5% for natural drying. The blasting rate, polished rice rate, and taste value of mechanically dried rice were 5.33%, 57.9%, and 83.7, respectively, which was 2.33%, 58.9%, and 89.3 for naturally-dried rice. The processing quality and taste quality were even worse. Therefore, the drying process of the optimized circulation dryer should be further adjusted to reduce its impact on rice processing quality and taste quality.

Key words: rice; natural drying; circulating dryer; processing quality; taste quality

1. Introduction

Rice is one of the world's major grains, and 50% of the world's population is rice-based. In China, as one of the three major grain consuming countries, the yield of rice ranks second only after corn. In 2017, China's rice cultivation area was 30 million hectares, and the output was about 210 million tons. The planting area and output all ranked first in the world. The moisture content of rice after harvest is usually high. At this time, the rice itself has a strong respiration. At the same time, the biological activity of grain reserves is intense. If it is not dealt with in time, it can easily cause adverse effects such as high temperature, germination, and mildew. According to statistics, China's high-moisture paddy after harvest was too late to reach the safe storage moisture content, resulting in losses of up to 5% in storage, transportation, and processing. Rice drying is a necessary processing step after harvest. Rice is a heat-sensitive grain, and unreasonable drying methods can cause changes in the physical and chemical characteristics of the main components of rice. Therefore, it is important to choose an effective and appropriate drying method. The natural drying method is a technique for ventilating and drying food by means of solar energy and natural wind in a natural environment. The natural drying method does not require special equipment. Although it is largely limited by weather conditions, it is still the main method of grain drying in China. With the rapid development of agricultural machinery, grain dryers have become more and more widely used. They can be roughly divided into continuous and circulating types. Compared to corn and wheat, rice has higher requirements for drying process due to its heat sensitivity, and circulating dryer with small batches and low temperature is more suitable.

In this experiment, removal of water was performed on high-water rice by using two drying modes: natural rice drying and circulating dryer. The changes of water and fungal spores in rice during the natural drying process were studied. The quality of the dried rice was compared between the two methods, and the differences in the changes were studied to provide reference for the effective and reasonable method of rice drying in the post-harvest treatment of rice.

2. Materials and Methods

2.1 Test materials

Test material was new rice that was harvested on September 13, 2017. The variety was Shenliangyou 5814, and the place of production was Xinjin County, Chengdu. The initial quality indicators of rice are shown in Tab.1.

Tab.1 rice intial quality indicators

Moisture（%）	Impurity rate（%）	Brown rice rate（%）	Thousand kernel weight（g）
23.11	1.83	76.36%	31.16

2.2 Test equipment

FA22048 Electronic Balance: Shanghai Jingke Tianmei Scientific Instrument Co., Ltd.; 101-1A Electric Heating Blast Drying Box: Beijing Zhongxing Weiye Co., Ltd.; JFSD-100 Crushing Machine: Shanghai Jiading Grain and Oil Instrument Company; JJSD Type Filter: Shanghai Jiading Grain and Oil Instrument Company; JLG-1 Huskers: Chengdu Grain Storage Research Institute, China Grain Storage; JNM-III Milling Machine: Chengdu Grain Storage Research Institute, Middle Grain Storage;

SMART Biological Microscope: Beijing Zhongxian Hengye Instrument and Meter Co., Ltd.; HPS-250 Biochemical incubator: Harbin Donglian Electronic Technology Development Co., Ltd.; JSWL rice taste detector: Beijing Dongfu Jiuheng Instrument Technology Co., Ltd. and Japan Satake Company; TH802A mechanical temperature and humidity meter: Meideshi Instrument Co., Ltd.; DTS418 type three-phase four Line Electronic Energy Meter: Changan Group Co., Ltd.

1.3 Test methods

1.3.1 Rice natural drying

Fig.1 Rice natural drying

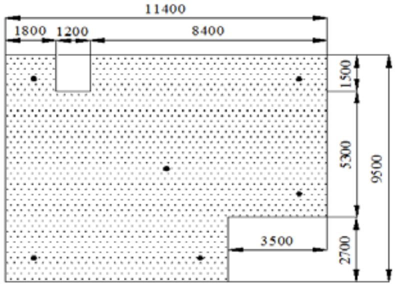


Fig.2 Sampling point layout

In accordance with the common farmer's pattern of grain drying, we chose a well-ventilated area to lay the wet rice on the cement floor under the shelter (Fig.1). The total weight of rice was 1.60t, and the area of the site was $11.4\times9.5-1.2\times1.5-3.5\times2.7=97.05m^2$, and the thickness was about 4cm. Samples of rice moisture content and fungal spores were routinely taken at 8:30 daily. The location of the sampling points was set as shown in Fig.2. Six sampling points were located at five corners and at the center. The sampling point on the corner was 1.00m away from both adjacent sides. The six sampling points can more fully reflect the change of moisture in the rice during the drying season. In accordance with the method of foodstuffs for farmers, daily sun drying was carried out. [Taking into account the relationship between autumn temperatures, the use of wooden clogs is repeated every day at 9:00 and 14:00.What does this mean?] We placed a thermometer and hygrometer on the drying area and recorded the temperature and humidity changes from 9:00 to 17:00 every hour.

2.3. 2 Rice mechanical drying

We used a mechanical dryer to dry 10.00t of the same batch of wet rice. Dryer model GuWang5HXG-15B, a cross-flow circulation dryer.

2.3.3 Determination of indicators

2.3.3.1 Determination of moisture content was according to GB/T 5497-1985. In the early drying period, the moisture content of rice exceeds 18%. Therefore, it was necessary to use two drying methods. The specific steps were: Weigh out 20g of rice (accurate to 0.001g), and put it in a baking box with a diameter of 10cm and a height of 2cm. Bake at 105±2°C for 30-40min. Take out and cool to constant weight. (The difference between two weighings does not exceed 0.005g. This is the weight of the sample after the first baking). After smashing the first baked rice sample, use an aluminum box that is baked to a constant weight, weigh about 3g of the sample (accurate to 0.0001g), put the aluminum box cover on the bottom of the box, and put it into the drying oven . Take it out after 105±2°C for 3 hours, remove it, cap it, place it in a desiccator and cool it to room temperature. Take it out and weigh it, then re-bake it according to the above method, take it out and cool and weigh it once every 30min, baking it before and after. The difference between the two weights should not exceed 0.005g. If the latter weight is higher than the previous weight, the previous weight is calculated. The moisture content of rice was calculated according to the following formula:

$$\text{Moisture}（\%）= \frac{W \cdot W_2 - W_1 \cdot W_3}{W \cdot W_2} \times 100$$

Where: W - the weight of the sample before the first baking, g;

W_1 - weight of the sample after the first baking, g;

W_2 - weight of the sample before the second baking, g;

W_3 - Sample weight after the second baking, g.

2.3.3.2 The number of fungal spores was determined according to the fungal spore count method proposed by Cheng et al. (2009). The specific operation procedure was: Take 10.0 g of rice sample, add 30 mL of deionized water in a 50 mL test tube, add stopper, shake vigorously for 1 min, and filter with 300 mesh. The cloth was filtered and the filtrate was counted under a microscope for fungal spores.

2.3.3.3 Determination of waist burst rate According to GB/T 5496-1985.

2.3.3.4 Determination of germination rate According to GB/T 5520-2011.

2.3.3.5 Determination of roughness According to GB 5495-2008.

2.3.3.6 Determination of the rate of polished rice According to GB/T 21719-2008.

2.3.3.7 Determination of fatty acid value According to GB/T 5510-2011

2.3.4 Test site

Chengdu Qingbaijiang National Grain Reserve of Sichuan Province

3. Results

3.1 Natural drying rice moisture changes

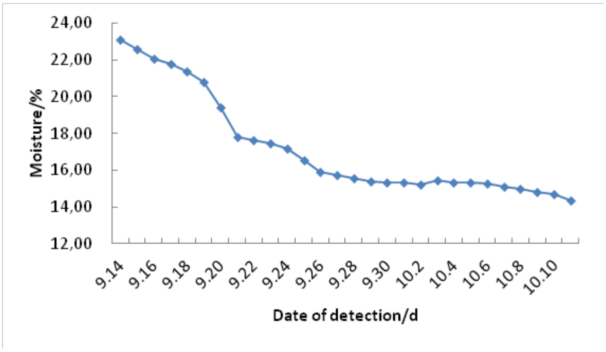


Fig.3 The curve of rice moisture

Tab.2 Daily precipitation and temperature and humidity of rice correlation analysis

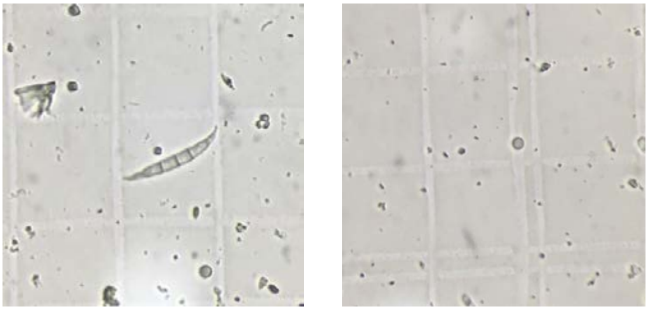
		Temperature	Relative humidity	Daily water loss?
Temperature	**correlation coefficient**	1.000	-0.502**	0.529**
	Sig.	-	0.009	0.005
Relative humidity	**correlation coefficient**	-0.502**	1.000	-0.220
	Sig.	0.009	-	0.281
Daily water loss?	**correlation coefficient**	0.529**	-0.220	1.000
	Sig.	0.005	0.281	-

Note: ** indicates a significant correlation at the α=0.01 level, and * indicates a significant correlation at the α=0.05 level.

As shown in Table 3, there is a positive correlation between daily water loss and temperature, and the correlation is extremely significant. The daily water loss is negatively correlated with the average relative humidity, and the correlation is not significant. Therefore, under the conditions of natural drying of rice in this experiment, the effect of temperature on the drying rate is greater than the humidity.

3.2 Rice fungi spores change during natural drying

During the natural drying, due to the slower rate of water loss, rice is in a state of unsafe moisture for a long time. Because the ambient temperature is not high, the external conditions are extremely suitable for the growth of fungi.



(a) Fusarium spore (b) Aspergillus niger spore

Fig.4 Microscopic view of fungal spores

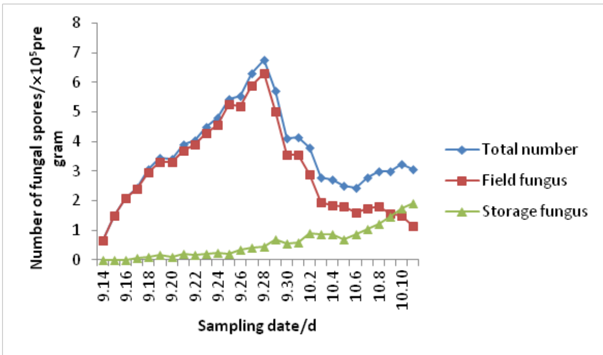


Fig. 5 The number curves of the of spores of rice fungal

Tab.3 The evaluation criteria of spoilage fungi spores in stored grains

Safty level	Fungal spores number	Safty
Level I	$<1.0\times10^5$	Security
Level II	$(1.0\sim9.9)\times10^5$	Critical control criticality
Level III	$(1.0\sim9.9)\times10^6$	Harm
Level	$\geq1.0\times10^7$	Serious harm

According to the ecological group, microorganisms can generally be divided into field fungi (infested by field growth, mainly parasitic and parasitism) and stored fungi (all kinds of saprophytic bacteria). Field fungi include *Alternaria*, *Fusarium*, etc., and storage fungi include *Aspergillus niger* and *Penicillium*[3]. Shown in Fig. 4 are the spores of the *Fusarium* spp. and *Aspergillus nigrum* under the microscope. During the experiment, samples were taken daily to detect field and stored fungal spores. A graph showing the change in the number of spores in rice cultivars is shown in Fig. 5. It can be seen from the figure that during the natural drying of rice, the total number of fungal spores first increased and then decreased. On September 28, the total number of fungal spores reached the maximum value of 6.75×10^5/g. According to Table 3, the number of fungal spores that are hazardous to rice is at the critical control threshold, although this did not reach the level of harm. However, there is a great threat to the safe storage of rice. During the whole drying period, the stored spores showed a gradual upward trend, and the number of spores in the field increased first and then decreased. Referring to Figure 3 and Figure 5, when the total number of fungal spores in the field reached the peak value, the rice water content was 15.55%. After that, the rice water reached a stable period with less than 1% change. Therefore, it is possible that the decrease in total moisture is the main reason for the decrease in the number of spores in the field.

3.2 Two methods of drying results analysis

Tab.4 Drying results in two ways

Dring method	Initial moisture (%)	Final moisture (%)	Drying amount (t)	Drying time (h)	Drying speed (1% moisture/h)
Natural drying	23.1	14.4	1.6	648	0.0134
Mechanical drying	23.1	11.8	10.0	5	2.26

Comparing Tab.4 with the drying results of two kinds of drying methods, it can be seen that natural drying has the characteristics of small treatment volume and slow drying speed, while mechanical drying has a large amount of processing and a high speed relative to rice batches.

3.3 Analysis of the impacts of two kinds of drying on rice quality

Tab.5 Rice crack ratio with two drying methods

Drying method	Natural drying	Mechanical drying
Crack ratio(%)	58.90±0.15a	57.90±0.36a

Note: Different letters represent significant differences, the same below.

The waist burst rate is an important indicator for assessing the drying process of rice. During the drying process, due to the different water loss rates of the inner and outer layers of the rice grains, a water gradient is generated, causing internal stress, and cracks appear when the stress exceeds the tensile strength of rice[4]. In the case of rice with a high waist rate, especially when the cracks are large and deep, it is not appropriate to process high-precision rice, otherwise it will increase broken rice and reduce the rice rate. Since the natural drying process does not assist the heating of rice, the waist rate is lower than that of the dryer. It can be clearly seen from Table 5 that the popping rate of natural dry rice is significantly lower than that of mechanical drying. [Table 5 shows no significant difference in crack rate between the two drying methods.] This is due to the high temperature environment in the mechanical dryer causing excessive water loss in the outer layer of rice grains.

Tab.6 Head rice yield with two drying methods

Drying method	Natural drying	Mechanical drying
Head rice ratio(%)	58.90±0.15a	57.90±0.36a

The head rice rate is the most important trait in the quality of rice milling, which affects the taste quality of rice to a large extent. Studies have shown that the higher the rate of whole polished rice, the greater the volume of rice swell and the better the quality of rice consumption[5]. According to Tab.6, it can be seen that the roughness of natural dry rice is significantly less than mechanical drying, and the percentage of whole rice is greater than that of mechanical dry rice, but the difference is not significant.

Tab.7 The germination rate of rice with two drying methods

Drying method	Natural drying	Mechanical drying
Germination rate (%)	87.5±5.5a	58.0±2.0b

The germination rate of rice is an important indicator for comprehensively measuring the new graininess of rice. The freshness of the rice and the quality of the food can be reflected by changes in the germination rate[6]. From Tab.7, it can be seen that compared with naturally-dried rice, the germination rate of mechanically dry rice is low, and the difference is significant. The results indicated that the vitality of natural air-dried rice embryos was well preserved, while the low-temperature circulation dryer had a lower hot air temperature than the continuous dryer, but it still had a strong destructive effect on the internal physiological structure of rice, which seriously affected the growth of rice.

Tab.8 Fatty acid value of rice with two drying methods

Drying method	Natural drying	Mechanical drying
Fatty acid value (mgKOH· $(100g)^{-1}$)	25.11±0.57a	19.8±0.90b

Rice lipids are oxidized to produce free fatty acids, which are represented by fatty acid values. Fatty acid values are an important indicator of rice freshness, and the extent of rice quality changes can be judged based on changes in fatty acid values [7]. It can be seen from Tab.8 that the fatty acid values of rice obtained by natural drying are significantly greater than those of mechanical drying, and the differences are significant. The growth rate of free fatty acid content is significantly positively correlated with the relative activity of lipase[8]. Since natural drying has a lower ambient temperature, lipase maintains a higher relative activity during the drying process. In addition, the natural drying time is lower. Longer, higher accumulation of free fatty acids may result in relatively higher values of natural dry rice fatty acids.

Tab.9 The taste value of rice with two drying methods

Drying method	Natural drying	Mechanical drying
Taste value(%)	89.3±0.41a	83.7±0.41b

The main principle of the taste meter is to accurately determine the components of amylose, protein, water, and fatty acids that determine the taste of rice by the difference in absorbance generated by the near-infrared light at a specific wavelength, and then to compare different ingredients data with experimental rice taste. The data is combined and scored by simple numerical values to objectively reflect the purpose of eating rice[9]. As shown in Table 9, the taste value of natural dry rice was significantly greater than that of mechanical drying, indicating that rotary bins can better protect the food quality of rice, while mechanical dried rice has the poorest food quality, and is significantly different from the former two.

4. Discussions

In this study, the water loss characteristics of naturally dried rice field were studied. At a temperature of 19.3°C and a relative humidity of 58.8%, a total of 28 days of water reduction from 23.11 to 14.38% was observed. The water loss of rice showed a trend of rapid change and slow change. The analysis of the correlation between daily water loss and ambient temperature and humidity shows that the daily water loss is positively correlated with the ambient temperature, and the correlation is significant. It is negatively correlated with the relative humidity of the environment and the correlation is not significant. During the drying period, the number of fungal spores in the rice field gradually increased in the early stage, began to decline after reaching the highest value on September 28, and the number of stored fungal spores gradually increased, and exceeded the number of field spores in the late drying period. Mechanical drying was performed using a Guwang 5HXG-15B circulating dryer. The drying temperature was set at 42°C, and the water content was reduced from 23.1 to 11.8% after a total of 5 hours. The changes of spore count, fatty acid value, germination rate, waist burst rate, whole polished rice rate, and taste value of rice mold after drying were studied. The results showed that compared with the mechanical drying, the natural rice has a lower popping rate, a higher rate of whole milling, and a better processing quality. The germination rate of the dried rice is much lower than that of natural dry rice. In addition, the fatty acid value of natural dry rice is greater than mechanical drying, which may be caused by the natural drying time is too long. Using the taste meter to comprehensively score the rice obtained by the two drying methods, the natural dry rice score was 89.3, which was greater than the mechanical drying of 83.7, and it was found that the nature of natural drying and taste was better.

Comparing the drying results of the two methods of drying rice, it can be seen that natural dry rice has a small amount of processing and slow precipitation, but it has a good protection effect on rice processing, germination, and taste quality. While mechanical drying is relatively large and rapid with respect to rice batches, it has a great influence on rice quality. With the increasing living standards of the people, more and more importance is attached to the quality of rice. Therefore, in the future research process, it is necessary to further improve the drying machinery technology and improve the quality of rice.

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Germination rates of frozen grain legume seeds in Cameroon

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Abstract

A project on collection and conservation of genetic resources was carried out in Cameroon in 2014 in villages around Yaounde, Mbalmayo, and Ebolowa. Samples of all grain legume species cultivated by the farmers were collected from the 15th of March till early May 2015. Farmers in these zones cultivate mostly ground nuts, followed by soybean and cowpea. A total of 39, 13, and 45 samples were collected from Yaounde, Mbalmayo, and Ebolowa, respectively. After collection, samples were sun-dried, treated, labeled, plasticized, and stored in the freezer at -20°C in the Institute of Agricultural Research for Development (IRAD) store room at Nkolbisson, Yaounde. A trial was carried out at IRAD Kumba experimental farms in 2016 to purify and maintain 14 cowpea and 12 groundnut samples from the freezer, under the C2D project. There were highly significant differences ($P < 0.05$) amongst samples (treatments) for the germination rate. Cowpea samples had a germination rate ranging from 0.33 to 47.67%, while germination rates for groundnuts were between16.67 to 68.33%. Out of the 26 samples, only 5 (19%) had germination rates above 50%. Due to irregular power supply, freezing turned out to be an ineffective storage method for grain legume seeds. Seeds are now being maintained in vivo in small quantities and on seasonal basis which renders the job of plants breeders very difficult and ineffective. Alternatives storage methods and facilities for grains and seeds in developing countries like Cameroon remain an urgent need to boost research and ensure food security.

Keywords: conservation, grain legume, germination, seeds, developing countries.

Introduction

Biodiversity is the third component of biological diversity (the other two being the specific diversity (the individuals) and ecosystem diversity (populations and their habitats)). Biodiversity may refer to wild biodiversity and agricultural biodiversity. Since the Conference in Rio de Janeiro in 1992 organized by the Convention on Biological Diversity (CBD), to which Cameroon is party, other international legal instruments have been put in place in order to ensure the implementation of the relevant provisions of the CBD. Among these instruments signed and/or ratified by Cameroon, we may cite the International Treaty on Plant Genetic Resources for Food and Agriculture on the