The effect of rice storage on the eating quality

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Abstract: This study investigated the impact of different storage temperatures on the quality of rice during an 11-month storage period. Rice is a crucial staple food, and maintaining its quality during storage is essential for food security. The research focused on moisture content and fatty acid value as key indicators of rice quality. Results showed that low-temperature storage, specifically at 0°C and 10°C, contributed to slower moisture loss and reduced lipid degradation compared to room temperature storage (25°C). This study underscores the significance of low-temperature storage in preserving the quality of rice over time.

1. Introduction

Rice, China is a major consumer of rice, due to the vastness of our country. With the development of science and economy, population mobility is increasing. However, due to the seasonality of rice production and the continuity of rice consumption, in order to satisfy people’s perennial needs, as well as from the perspective of national strategy and disaster mitigation and prevention, the state has implemented a macro-control policy on rice consumption and has stockpiled rice. China's existing central reserve quantity is mainly concentrated in the main grain-producing areas, and the sensitive areas of our grain market are mainly concentrated in the southeast coast and other main grain marketing areas, such as Zhejiang, Jiangsu, Shanghai, Guangdong, Hainan and so on [1]. As well as the regional layout of China’s central grain reserves, from the development trend of rice logistics, China’s main flow of grain tends to “northern grain south” pattern, in which rice mainly from Heilongjiang Province to the east and south China, to ensure that part of China’s densely populated cities and cities from the main rice production area. This ensures that some densely populated cities in China are able to transfer rice from the main rice-producing areas.

Rice is one of the most difficult grains to preserve, as the endosperm-protecting hulls and skins are removed during rice processing, and the endosperm is directly connected to the endosperm. Because the endosperm and the skin layer protecting the endosperm are removed during rice processing, the endosperm is directly linked to the external environment with factors such as temperature and humidity [2]. Hydrocolloids rich in starch, protein, and other nutrients, are very susceptible to moisture, heat, oxygen, insects, mold, and other influences and deterioration. Especially in the summer high temperatures, high humidity conditions, the quality of rice deterioration, and mold speed up, resulting in increased acidity, and viscosity decline, so that the rice food quality decline or even loss of food value. The quality of rice decreases and even loses its edible value [2-3]. In order to maintain the freshness of rice, people need to preserve the freshness of rice. In order to maintain the freshness of rice, people need to store rice in freshness preservation, and among the various storage methods of rice, low-temperature storage has significant superiority over other storage methods.

First of all, low temperatures can effectively limit the life activity of grain heap organisms, reduce the infection of pests and microorganisms on the grain heap, and reduce the loss of stored grain. In addition, low temperature can inhibit various physiological and biochemical reactions within the grain, effectively slowing the Effectively slow down aging of rice. In particular, can make the rice safe summer, preservation effect is remarkable. Finally, low temperature. Finally, the low temperature has no or fewer chemical reagents, can avoid or reduce the chemical pollution of rice, and maintain the storage of grain hygiene characteristics [4]. Therefore, low-temperature storage in rice green storage occupies a dominant position, more and more rice. More and more rice processing enterprises and rice transportation and marketing enterprises adopt low-temperature storage of rice. Due to the vastness of China's geography, different regions have significant environment at the same time, and due to the different geographical locations of the rice production enterprises, the different regions of the enterprises are ambiguous about the safe storage period of rice, especially in the high temperature and high humidity environment in the south of the country quality change of rice is also incomplete [5-6]. Reasonable control of the change rule of rice quality indexes to achieve both the change rule of rice quality indexes can be reasonably controlled to achieve both safe storage of rice and ensure its processing quality and flavor.
quality, and to clarify the safe storage period of rice under different environmental conditions. The period of safe storage of rice under different environmental conditions is clearly defined to provide technical guidance to grain and oil processing and warehousing enterprises, to reduce the loss of rice, and to eliminate the impact of inferior rice on the elimination of the loss of rice. It is of great practical significance for grain and oil processing and warehousing enterprises to provide technical guidance to reduce rice losses and eliminate the safety hazards caused by inferior rice to consumers [5].

2. Domestic and international research status

Rice during storage, with the extension of storage time, the Its physical and chemical properties undergo a series of changes, mainly manifested in the metabolism of the rice grains, enzyme activity decreases and Respiratory strength is weakened, which is a phenomenon of natural aging of rice [6]. The main internal causes of rice aging are changes in proteins, changes in straight-chain starch, changes in lipids, reducing sugars, and changes in enzyme activities. These changes do not occur in isolation, but These changes do not occur in isolation, but interact and constrain each other, leading to changes in cooking quality, volatile odor, and microstructure of rice during storage, and ultimately affecting its eating quality. These changes do not occur in isolation but interact with each other, leading to changes in cooking quality, volatile odor, and microstructure of rice during storage, and ultimately affecting its eating quality.

2.1 Changes in moisture

Moisture in rice accounts for about 14% and is one of the main factors affecting the quality of rice. Water content The amount of viscosity with the size of the rice, hardness, and taste quality is closely related to the water content too high will make the surface of the rice Too high water content will make the microorganisms on the surface of rice grow and reproduce vigorously, resulting in shortening the shelf life, while too low water content may lead to poor taste of rice, resulting in lowering the quality of rice [7]. Too low a moisture content may lead to poor taste of rice, resulting in a reduction in the quality of rice, while a suitable moisture content in rice helps to maintain its eating quality. According to literature According to the literature [2], the change of water content in rice is essentially the change of free water content, in fact, there are a lot of small voids between rice starch granules so that the water content of rice can be reduced. In fact, between the rice starch granules, there are a lot of small gaps, so free water can easily pass through these gaps in and out of the cell, resulting in the water in the rice during storage. The water content of rice changes during storage.

2.2 Protein changes

Rice protein, as a high-quality plant protein, contains 20 amino acids and 8 essential amino acids. It has a much higher biomass value than wheat, corn and soybeans. During the storage period, the total protein content of rice remains basically unchanged. During storage, the total protein content of rice remains basically unchanged, and the main changes are in the structure and type of proteins. Among them, clear protein, globulin and alcohol-soluble protein remained largely, and alcohol-soluble proteins remained generally decreasing, whereas glutenin showed an increasing trend. Studies have shown that [7] under high temperature and high humidity, the stability of globulin is destabilized, and the physical properties of globulin are destabilized under high temperature and high humidity conditions, resulting in changes in the physical properties of globulin and a decrease in its solubility, which may contribute to the decrease in globulin content. Whereas the increase in the content of glutenin during storage may be due to the conversion of other component proteins. Proteins in storage process, affected by light and heat in the air, hydrolysis and denaturation occur, producing free amino acids, so that the protein in rice The spatial structure of the proteins in rice changes, the sol becomes a gel, and the acidity increases, leading to rice aging.

2.3 Changes in starch

Starch, which accounts for about 70% or more of the starch, is the most important component of rice and is generally categorized into straight-chain starch and branched-chain starch. Some related literature shows [4] that the composition content of these two kinds of starch in different kinds of rice exists differently, and the ratio and interrelationship between them will have different effects on the physicochemical properties of rice, which in turn affect the taste and consumption of rice [16]. The amylose content also has a significant effect on the cooking process, pasting, rheology, thermal properties, and texture of rice. The amylose content plays a crucial role in the cooking process, pasting, rheology, thermal properties, and texture of rice. A large number of studies at home and abroad have found that [3], the starch content of rice in storage aging phenomenon, the content of soluble straight-chain starch gradually decreased, while the content of insoluble straight-chain starch increased, and the direct result of this phenomenon is that the hardness, viscosity, and texture of cooked rice is The direct result of this phenomenon is that the hardness, viscosity, and texture of the cooked rice are poor. Previous studies have also investigated the molecular structure changes of branched-chain starch during rice storage and its relationship with the aging process. Previous studies have also explored the molecular structure of branched-chain starch during rice storage and its relationship with the physicochemical changes caused by aging [15], and found that after 9 months of storage, the starch pasting temperature was higher than the starch pasting temperature. It was found that after 9 months of storage, the decrease in starch
pasting temperature was related to the decrease in the proportion of long-chain branched starch [6].

### 2.4 Lipid changes

Although the lipid content of rice is small, only about 1%, it is rich in lipid fatty acids. Among them, linoleic acid accounts for 50%. In the process of grain storage, lipids due to the influence of external conditions, hydrolysis occurs, so that the free fatty acid content increases. The unsaturated free fatty acids continue to oxidize, producing aldehydes, ketones, and phenols [9]. This results in grain rancidity, which is not the fatty acid value of newly harvested rice grains in the range of The fatty acid value of newly harvested rice grains is 10-15mgKOH/100g, and with the extension of storage time, the fatty acid value of rice grains will increase. With the extension of storage time, the fatty acid value of rice grains increases slowly, but when improper storage conditions are used, the rate of rice rancidity will be exacerbated. However, under improper storage conditions, the rate of rancidity of rice will be aggravated [14].

### 2.5 Changes in sugars and amino acids

The two main groups of substances, sugars, and amino acids, as the main soluble components in rice, affect the taste of rice. taste. During storage, their contents change to some extent. The change in soluble sugar content is relatively complex, and its changes affect the sweetness of rice. On the one hand, in the storage process, the glycosidic bond in rice starch is interrupted by various amylases, leading to the decomposition of glucose maltose and other oligosaccharides [13], which makes the reducing sugar content in the rice starch constantly rise. The reduced sugar content is in a state of increasing [4]. On the other hand, rice itself contains a small amount of oligosaccharides.

On the other hand, rice itself contains a small number of oligosaccharides, such as glucose, fructose, maltose and sucrose. During storage, maltose will decompose to form glucose and sucrose will decompose to form fructose and glucose, resulting in an increase in the content of fructose and glucose and maltose and sucrose [12]. In addition, rice in storage time will also appear mold phenomenon, at this time a large number of microbial reproductions, in order to maintain their normal growth, reproduction, and In order to maintain its normal growth, reproduction, metabolism of life activities need to consume a large number of sugar substances, resulting in a decline in sugar content [3]. Changes in the amino acids in rice affect the flavor of rice, and some studies have shown that the fresh, bitter and sweet amino acids in rice can be reduced during storage. It has been shown that the fresh, bitter, and sweet amino acids in rice change to different degrees during storage, and under room temperature storage conditions [12], the total content of free amino acids gradually decreases. The total content of free amino acids gradually decreases under room temperature storage conditions [9].

### 2.6 Enzyme changes

Rice skin is rich in fat oxidase, alpha-amylase, catalase, hydrolase and many other enzymes. Changes in enzyme activity have an important correlation with physiological changes in grains, and the life activities of rice seeds are accomplished under the reaction of enzymes. During storage, the enzyme activity decreases and the physiological activities of rice slow down or even disappear, leading to rice staling. Studies have shown that fat oxidase shows a monotonic increase during storage, and fat oxidase uses free linoleic acid as a substrate to produce fat peroxides further decomposed into aldehydes and ketones, leading to rice staleness [7]. Amylase gradually decreases until it loses its activity with the extension of the storage period, leading to the rise of insoluble straight-chain starch, which makes the texture of stale rice much worse than that of new rice [8]. Zhou Xianqing mentioned in his article that catalase has a destructive effect on hydrogen peroxide affecting the seeds, and newly harvested rice seeds have a high level of catalase, which decreases with the extension of the storage period, and at the later stage of storage, catalase activity disappears completely, leading to deepening of the degree of staleness [9].

### 3. Effect of storage temperature on storage quality of rice

With the spread of the greenhouse phenomenon, the global average surface temperature is gradually increasing, and it is expected that the surface temperature will increase by 1.4-5.8 °C by the end of the century. The increase in temperature not only seriously affects the production of rice, but also poses a new challenge to rice storage, so it is very important to choose the appropriate temperature for storing rice.

#### 3.1 Experimental Materials and Methods

The rice harvested in the fall of the year was processed into fresh japonica rice, which was vacuum-packed, transported to the laboratory, and then redistributed in polyethylene bags. The rice was vacuum-packed and transported to the laboratory, where it was repacked into polyethylene bags and sealed for storage. The storage conditions were 0°C, 10°C, room temperature (25°C) and 70-80% ambient humidity. Samples stored at room temperature were used as controls. All samples were ground in a pulverizer prior to each analysis and the samples were sieved through a 100-mesh sieve.

#### 3.2 Measurement items and methods

The moisture content in rice was determined using the direct drying method with minor modifications. The moisture content
in rice was determined using the direct drying method with minor modifications. Each sample (about 5 g) was placed in a flat weighing bottle and weighed before use. The samples were dried at 105 °C for 5 h. The samples were then placed in a drying chamber. The samples were dried at 105°C for 5 h, cooled in a desiccator for 0.5 h and weighed. The sample is then dried and weighed again until the weight is constant. The sample is then dried and weighed again until the weight of the rice is constant.

3.2.1 Determination of moisture content

Place the figure as close as possible after the point where it is first referenced in the text. If there is a large number of figures and tables it might be necessary to place some before their text citation. If a figure or table is too large to fit into one column, it can be centered across both columns at the top or the bottom of the page.

3.2.2 Determination of fatty acid content

About 5 g of pulverized and sieved rice flour and 25 mL of anhydrous ethanol were placed in a conical flask and shaken for 30 min and then filtered. Take 12.5 mL of the filtrate into a beaker and add the filtrate to 25 mL with distilled water, then add 3–5 drops of phenolphthalein-ethanol to 25 mL, and then add 3–5 drops of phenolphthalein-ethanol solution as a color developer to mix. It was then titrated with 0.05 mol/L KOH/C5H5OH to obtain the final titration volume (V1). A reagent blank of 12.5mL of anhydrous ethanol was taken as control (V0).

The fatty acid values were calculated in mg/100g using the following formula.

\[ X = (V_1 - V_0) \times 56.1 \times m \times \frac{100}{12.5} \times \frac{m}{m + (100 - w)} \times 100 \]

where c is the concentration of KOH/C5H5OH standard solution (mol/L), 25 is the volume of anhydrous ethanol used for sample extraction (mL), 12.5 is the volume of filtrate used for titration (mL), m is the mass of sample (g), w is the volume of filtrate used for titration (mL), and m is the mass of sample (g). volume (mL), 12.5 is the volume of filtrate used for titration (mL), m is the mass of the sample (g), and w is the mass of water per 100 g of rice (g). m is the mass of sample (g), and w is the mass of water per 100 g of rice (g).

3.2.3 Determination of Water Solubility Index (WSI) and Water Absorption Index (WAI)

WSI and WAI were determined according to the method described by Kraithong et al.[11] with some modifications. About 1.0 g of rice flour and 15 mL of distilled water were placed in a centrifuge tube and shaken well. The centrifuge tubes were shaken well, and then placed in a water bath. The supernatant was heated in a water bath shaker at 200 r/min for 30 min, cooled to room temperature and then centrifuged at 4000 r/min for 20 min. The supernatant was poured into a weighing flask and dried in a desiccator at 105°C until constant weight. The precipitate was collected and weighed. WSI and WAI were calculated as follows:

\[ \text{WSI} (%) = \frac{\text{mass of dried supernatant (g)}}{\text{mass of rice (g)}} \times 100 \]

\[ \text{WAI (g/g)} = \frac{\text{mass of sediment (g)}}{\text{mass of rice (g)}} \]

3.3 Results and Discussion

After being processed into rice, paddy still belongs to the organic living organisms, and water, as a medium for various physiological and biochemical reactions within rice, is indispensable for material decomposition, transportation, and synthesis [5]. Medium for various physiological and biochemical reactions to take place, and it is indispensable for the decomposition, transportation and synthesis of substances [5]. Higher water content in rice When the water content in rice is high, the cellular respiration rate will be accelerated, which is not favorable for storage, and excessive water also helps the growth and reproduction of microorganisms, which accelerates the deterioration of quality. On the other hand, if the rice moisture content is low, it will lead to rice on the contrary[10], if the moisture content of rice is low, it will lead to dryness and cracking phenomenon, which will affect the eating taste and appearance quality if it is more serious. In addition to its own internal

In addition to its own moisture, but also due to the adsorption of the rice surface moisture to the internal diffusion of the formation of the part of the Therefore, storage conditions can affect the moisture content of rice [6]. Figure 1 shows the variation of moisture content of rice with storage time under different storage conditions. Figure 1 shows the variation of moisture content of rice with storage time under different storage conditions, and it was found that the moisture content showed a decreasing trend during storage. It was found that the moisture content tended to decrease during the storage period. After 11 months of storage, the moisture content of rice at 0°C, 10°C, and room temperature was 2.90% lower than that of fresh rice, respectively. After 11 months of storage, the moisture content of rice at 0°C, 10°C and room temperature decreased by 2.90%, 9.42%, and 16.08%, respectively, compared with that of fresh rice, which may be due to the respiration, metabolism, and other factors of the rice itself.

![Changes in moisture content of rice during storage at different temperatures](image-url)

Figure 1. Changes in moisture content of rice during storage at different temperatures
The fatty acid value is one of the important parameters reflecting the deterioration of rice storage quality \(^3\), the larger the fatty acid value, the more serious the deterioration of rice quality, the less suitable for storage. As shown in Figure 2, the fatty acid content of fresh rice was 10.49 mg/100 g. After 11 months of storage, the fatty acid content of rice increased compared with that of fresh rice, and the fatty acid content increased to 15.75 mg/100 g, 18.60 mg/100 g, and 25.78 mg/100 g at the storage temperatures of 0℃, 10℃, and room temperature, respectively. Moreover, the fatty acid content of rice increased to 15.75 mg/100 g, 18.60 mg/100 g, and 25.78 mg/100 g at the same storage time. Same storage time, the higher storage temperature (room temperature) was significantly higher than the fatty acid values of rice stored at lower temperatures (0℃, 10℃) (Figure 2) (p<0.05). During the 11th month storage period, the fatty acid values of rice stored at room temperature were 63.60% and 38.52% higher than those stored at 0℃ and 10℃, respectively, which indicated that the fatty acid values of rice at higher temperatures changed faster, which was in agreement with the research results of Park et al \(^2\). The results were consistent. This is mainly due to the fact that during storage rice is subjected to light, air, and water. This is mainly due to the fact that during storage, rice is exposed to light, air, and moisture, which destabilizes the lipid components present, hydrolyses free fatty acids, and oxidizes hydroperoxides and other secondary products, resulting in changes in fatty acid content \(^4\). Hydrolysis, rancidity, and oxidation of lipids are more pronounced, especially at high temperatures, which oxidize aldehydes and ketones in rice molecules, resulting in faster rates of oxidative synthesis and metabolism \(^8\). In addition, the increase in microbial population also causes an increase in the fatty acid content of rice during storage \(^7\).

### 3.3.1 Discussion

Through the determination of moisture content and fatty acid content indexes of rice at three different storage temperatures, namely 0℃, 10℃, and room temperature, we investigated the changing law of physiological and biochemical characteristics of rice stored at low temperatures for 11 months. The results show that low-temperature storage can slow down the deterioration of rice quality. The moisture content of rice at the three storage temperatures decreased gradually during the storage period, and the lower the temperature, the slower the trend of decrease. The fatty acid content of rice increased continuously during storage and rose faster at higher storage temperatures, indicating that lower temperatures can slow down the degradation of lipids. In conclusion, when rice was stored at low temperatures, water loss was reduced, and various quality changes of rice were suppressed.

### 4. Conclusion

In conclusion, this study examined the effects of storage temperature on the quality changes in rice over an 11-month period. The findings revealed that low-temperature storage, particularly at 0℃, significantly mitigated the deterioration of rice quality. The moisture content of rice decreased gradually during storage across all temperatures, with lower temperatures showing a slower rate of decrease. Additionally, the fatty acid content in rice increased steadily during storage, with higher temperatures leading to a faster increase\(^5\). These results highlight the effectiveness of low-temperature storage in minimizing water loss and suppressing various quality changes in rice. As such, implementing low-temperature storage methods can prove crucial in maintaining the freshness, flavor, and overall quality of rice, especially in the face of increasing temperature challenges brought about by environmental changes.

### References

6. Song Ting. Law analysis of the influence of different milling degrees on rice quality during rice storage [D]; Heilongjiang Bayi Land Reclamation University, 2016.

![Figure 2. Changes in fat acidity of rice during storage at different temperatures](image-url)


