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The Effects of Different Harvesting Periods on the Moisture Content, Whole Kernel Rate and Eating Quality of Rice

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Abstract The timing of rice harvest often goes unnoticed in terms of its impact on quality, yet it is crucial in actual production. This study starts from this issue, observing the differences in rice quality at various time points as the harvest period changes. Three scenarios were set up in the experiment: early harvest, timely harvest, and late harvest. The moisture content of grains, the rate of whole and well-polished rice, and the eating quality of rice were measured and compared. The results show that the harvest time directly affects quality. Early harvest leads to high moisture content in grains, insufficient maturity, significantly lower rates of whole and well-polished rice, and poor eating quality of rice. At the appropriate harvest stage, the moisture content of grains remains at about 20%-25%, the rate of whole and well-polished rice is at a high level, and the eating quality is the best. If the harvest is too late, the moisture content of grains is too low, which can cause cracks, the rate of whole and well-polished rice decreases, and the eating quality also weakens. Considering all the performances, it can be seen that there is a relatively suitable harvest period range for the tested variety, during which both yield and processing quality and eating quality can be ensured. The relevant conclusions can provide a reference for the reasonable arrangement of harvest time in production and the improvement of the output level of high-quality rice.
Keywords Harvest period; Moisture content; Rate of whole and well-polished rice; Eating quality; Rice quality

1 Introduction

In field management, harvesting is often regarded as the final step, but in many cases, the problem lies precisely here. Some people are worried about reduced yields if they delay, so they start early. However, the grains have not fully matured and the rice is not fully plump, resulting in a decline in quality. Others choose to wait longer, but waiting too long is not necessarily the best option either. Once the grains become too dry, more grains fall off, and the whole rice purity rate and taste will be affected. In reality, there is rarely a "one-time perfect" timing. The harvest period is determined through repeated considerations. In recent years, consumers are more concerned about whether the rice is good to eat rather than just about high yield. This has made the importance of the harvest time even more prominent. The research around this aspect is not complicated in purpose. It is to provide producers with a more reliable reference. Under the condition of not reducing yield, it aims to advance the quality of the rice one step further (Du et al., 2023; Zhou et al., 2025).

When discussing the quality of rice, many indicators are often considered together, such as grain moisture content, whole rice purity rate and taste performance. However, the actual situation does not always match up. Generally, it is believed that controlling the moisture content at 22% to 26% during harvesting is more beneficial for the whole rice purity rate. This is only a general experience and does not apply to all varieties. For example, some hard rice with a high level of amylose content, even if the whole rice purity rate is not low, the taste of the cooked rice may deteriorate. Therefore, good processing quality does not necessarily mean good taste. Currently, there are not many studies on how changes in the harvest period simultaneously affect moisture content, processing quality and taste. The interaction relationship between the three is still unclear, which leaves room for further in-depth analysis (Teng et al., 2024; Zhou et al., 2025).

Regarding the optimal time for harvesting rice, this study did not focus solely on a single indicator. The

experiment was conducted directly in the field. By setting different harvest times, the moisture content of the grains, the whole grain milling rate, and the eating quality were measured respectively. These results were then compared together to see if the changes were synchronous. Unlike previous discussions that broke down the issues separately, here an integrated analysis approach was adopted, combining factors such as moisture content, processing effects, and eating quality. This was done in conjunction with the actual responses of specific varieties to verify the results. The purpose of this approach is also quite clear; it is to make the experimental results more closely align with actual production conditions, and at the same time, provide more practical references for the harvesting management of high-quality rice.

2 Changes in moisture content of rice during different harvest periods

2.1 Dynamic changes in moisture content during the ripening process of rice grains

During the later growth stage, the moisture content in the rice does not drop all at once; instead, it changes gradually. For instance, during the milk stage, the moisture content in the grains is still relatively high. Only when the filling process continues does the moisture content start to decrease. In the late wax ripening stage, this decrease becomes more pronounced. When approaching full maturity, the moisture content often drops to around 20%. In actual production, it is not necessary to wait until complete maturity to plant the rice. It is generally more suitable to do so between the end of the wax ripening stage and the early stage of full ripening. At this time, the moisture content of the grains is mostly between 20% and 25% (Zhou et al., 2025). At this point, the rice has turned yellow in color, the grains are plump and have a hard texture, and the moisture content is relatively stable. Whether for harvesting or subsequent processing, this is more convenient (Teng et al., 2024).

2.2 Differences in the impact of different harvesting periods on grain moisture content

In actual production, the moisture content of grains varies significantly depending on the time of harvest. Generally, the moisture content of rice harvested earlier is the highest, while at the appropriate harvesting stage, the moisture content of the grains is usually around 20%; if the harvest is further postponed, the moisture content will further decrease, even dropping below 15% (Zhou et al., 2025). Field management experience also indicates that rice with excessive moisture is not conducive to later storage, and rice with insufficient moisture can also cause problems (Wang et al., 2022). Both harvesting too early or too late carry risks. Therefore, in production practice, the harvesting time needs to be flexibly adjusted according to the changes in grain moisture content to maintain it within a relatively appropriate range, so as to avoid increasing drying costs or having adverse effects on quality.

2.3 Relationship between moisture content changes and meteorological factors

Once the grains reach the mature stage, the changes in moisture content tend not to be as predictable as expected. They do not always follow the growth process all the way down. Instead, weather becomes a crucial factor. For instance, when there are many sunny days and the air is dry, the grains lose moisture at a significantly faster rate. However, if there are several consecutive rainy days, the moisture content may be pulled back (Thompson et al., 2022). There is another situation that is often overlooked. When the moisture content has dropped below 16%, and then comes rain or dew to absorb moisture again, cracks are more likely to appear inside the rice grains, and the whole rice purity rate will also be affected (Figure 1) (Brinkhof et al., 2025). Therefore, when determining the harvest time, one should not only consider the maturity level but also pay more attention to weather changes. Try to avoid periods when rain occurs in concentrated bursts and reduce the adverse impact of significant fluctuations in moisture content on the quality of the rice.

3 Impact Mechanism of the Harvest Period on the Whole-Grain Milled Rice Rate

3.1 Relationship between moisture content and breakage rate during rice milling

Many people focus on the milling process, but they overlook an earlier issue. In fact, this problem becomes apparent even during the harvesting stage. The key lies in the moisture content of the grains. When the moisture level is too high, during the subsequent threshing and drying processes, fine cracks are more likely to be left; but if the moisture level is too low, the rice grains become hard and brittle, and they are more likely to break when entering the milling machine. Because both extremes are unsatisfactory, in production, a balance must be found in

the middle. Generally, the moisture content is controlled within the range of 22% to 26% (Zhou et al., 2025), which is consistent with research showing that the highest head rice rates and quality traits are achieved when harvest moisture is around 22%~24% rather than much higher or lower values . This way, the situation of broken grains will be reduced, and the whole polished rice rate will be more stable. In the end, whether the moisture is properly controlled during harvesting directly affects the subsequent milling effect (Li et al., 2022), with harvest moisture content identified as a key factor affecting head rice yield and milling breakage in mechanical threshing studies

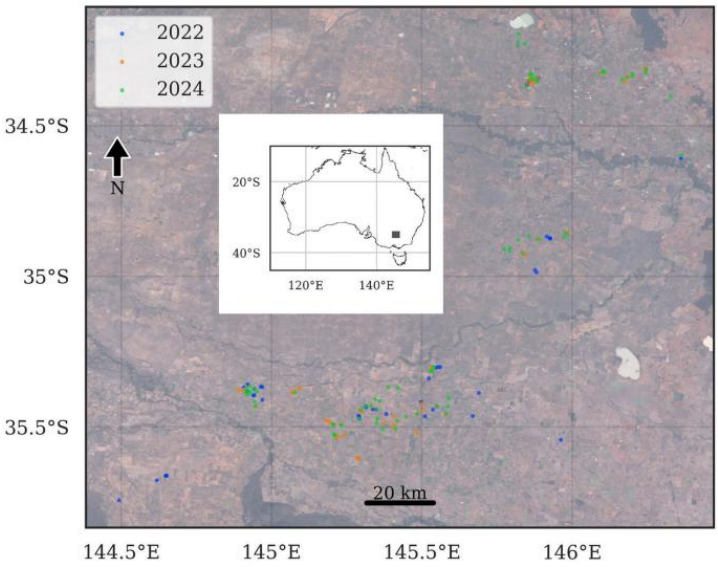

Figure 1 Map of sites where rice grain moisture content was sampled each year (total of 247 sites); the inset shows the study area in relation to Australia (Adopted from Brinkhof et al., 2025)

3.2 Changes in the whole-germ rice milling rate at different harvest times

In actual production, the whole polished rice rate does not always increase steadily. The results vary significantly depending on the harvest time. Generally, the milling effect is the best when the rice is about to mature. If the harvest is done too early, there will still be many unripe grains in the fields, and the whole polished rice rate will naturally not be able to increase. However, if it is delayed, the moisture content of the grains will drop too low, making them hard and dry, and the rate of broken grains will significantly increase (Zhou et al., 2025). If the harvest is not done at an ideal time, both the beginning and the end will be unsatisfactory, and only the middle period will show a more suitable time. During this period, it is easier to obtain a higher whole polished rice rate. If it is done too early or too late, the quality of the harvested grains will be affected (Figure 2) (Zhang et al., 2025).

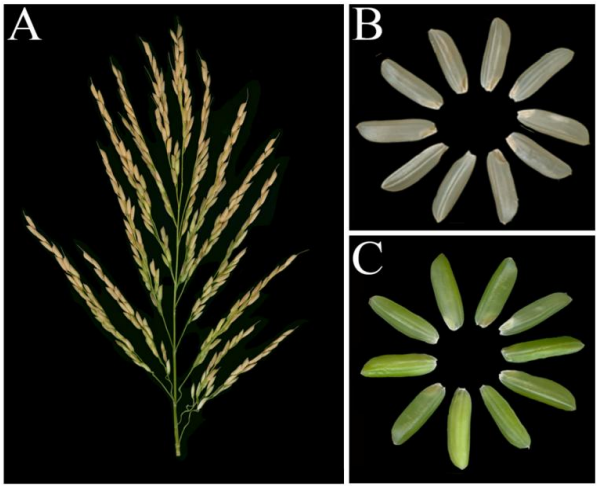

Figure 2 Maturity of rice grains at harvesting time: (A) for the whole panicle, (B) for mature grain, and (C) for immature grain (green grain) (Adopted from Zhang et al., 2025)

3.3 Physiological and physical mechanisms for regulating the whole-grain rice yield rate

When discussing the whole-grain rice yield rate, the harvest period is often an unavoidable factor, but the way it affects the result is not simple. For example, if the harvest is too early, the grains may appear to be fully formed on the surface, but their interiors are not yet fully filled. The endosperm structure is loose, and the mottling is obvious. During the milling process, they are prone to breakage; while if the harvest is delayed, the moisture content of the grains decreases too much, and combined with the repeated dry-wet changes in the field, cracks are more likely to form inside (Zhou et al., 2025). In contrast, rice harvested at an appropriate time point has a more balanced maturity and moisture condition, which avoids the problem of under-ripeness and reduces the risk of dry cracking (Teng et al., 2024). Naturally, the broken grains are fewer, and the whole-grain rice yield rate is more likely to remain at a high level.

4 Impact of Harvesting Period on Rice Flavor Quality

4.1 Effects of different harvesting periods on rice sensory quality

When rice is harvested at different times, both its taste and appearance will change, which is more obvious in practice. For example, if the harvest is too early, the rice grains have not fully developed and the aroma is not strong when cooked. There is often a hint of grassiness. When the harvest is at the appropriate time, the rice grains are plump and transparent, and the aroma and taste after cooking are more harmonious, and they are easier to be accepted (Sultana et al., 2023). However, if the harvest is too late, the rice grains have been dried for a long time, and the flavor will gradually fade, even giving a sense similar to aged rice. The rice will also be harder. Due to such significant differences, controlling the harvesting period within an appropriate range can better ensure the appearance and flavor quality of rice, meeting consumers' expectations (Khan et al., 2021).

4.2 Impact of harvesting period on amylose content and gel cohesiveness

When evaluating the quality of rice, the content of amylose and gelatinization degree are often mentioned. However, these two indicators are more influenced by the variety itself rather than the timing of harvest. Even if the harvest time is slightly earlier or later, the changes will not be too significant as long as it is within the normal range (Figure 3) (Zhang et al., 2025). Some studies have already pointed out that for most varieties, the content of amylose remains relatively stable under different harvest periods. In this experiment, a similar situation was observed. Regardless of whether it is amylose or gelatinization degree, the differences between different treatments were not prominent (Lu et al., 2025). Overall, compared to processing performance or flavor changes, the impact of harvest time on the starch-related qualities within the rice is not significant.

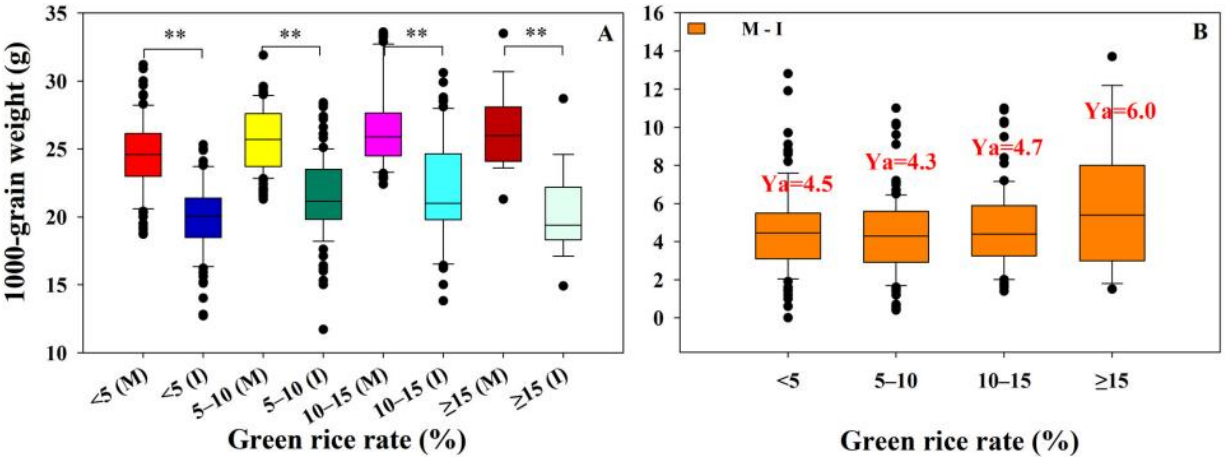

Figure 3 The 1000-grain weight of mature and immature rice (A), the difference in 1000-grain weight between mature (M) and immature (I) rice (M-I) (B). <5, 5-10, 10-15, and ≥15 mean the 50.20% 24.50% 13.70% 11.60% 25.30% <5% 5%-10% 10%-15% ≥15% Figure 3. The 1000-grain weight of mature and immature rice (A), the difference in 1000-grain weight between mature (M) and immature (I) rice (M-I) (B). <5, 5-10, 10-15, and ≥15 mean the green rice rate was lower than 5%, from 5% to 10%, 10 to 15%, and beyond 15%, respectively. ** represents the 1000-grain weight significant difference between mature and immature at the level of $p < 0.01$. Ya are the average differences in 1000-grain weight between mature and immature rice in each green rice rate threshold (Adopted from Zhang et al., 2025)

4.3 Correlation between moisture content and flavor quality indicators

When evaluating the quality of rice, the content of amylose and gelatinization degree are often mentioned. However, these two indicators are more influenced by the variety itself rather than the timing of harvest. Even if the harvest time is slightly earlier or later, the changes will not be too significant as long as it is within the normal range (Zhou et al., 2025). Some studies have already pointed out that for most varieties, the content of amylose remains relatively stable under different harvest periods. In this experiment, a similar situation was observed. Regardless of whether it is amylose or gelatinization degree, the differences between different treatments were not prominent (Teng et al., 2024). Overall, compared to processing performance or flavor changes, the impact of harvest time on the starch-related qualities within the rice is not significant.

5 Comprehensive Relationship Analysis of Moisture Content, Whole-Grain Rice Rate and Flavor Quality

5.1 Correlation analysis of different quality indicators

Based on the test results, the various qualities of rice are not necessarily better when the numerical value is higher. In many cases, they actually interfere with each other. For instance, some varieties with high amylose content and hard rice texture may have an improved whole-milled rice rate, but the taste score when eaten actually decreases (Tao et al., 2019). The processing effect and flavor do not simultaneously improve. Looking at it from another perspective, the moisture content also plays a key role: within an appropriate range, the whole-milled rice rate and flavor tend to be stable; however, if the moisture content is too high or too low, both aspects will be affected (Zhou et al., 2025). These situations remind us that improving the quality of rice cannot focus solely on a single indicator. Instead, it is necessary to repeatedly weigh different quality performances and find a relatively appropriate balance point (Figure 4) (Brinkhof et al., 2025).

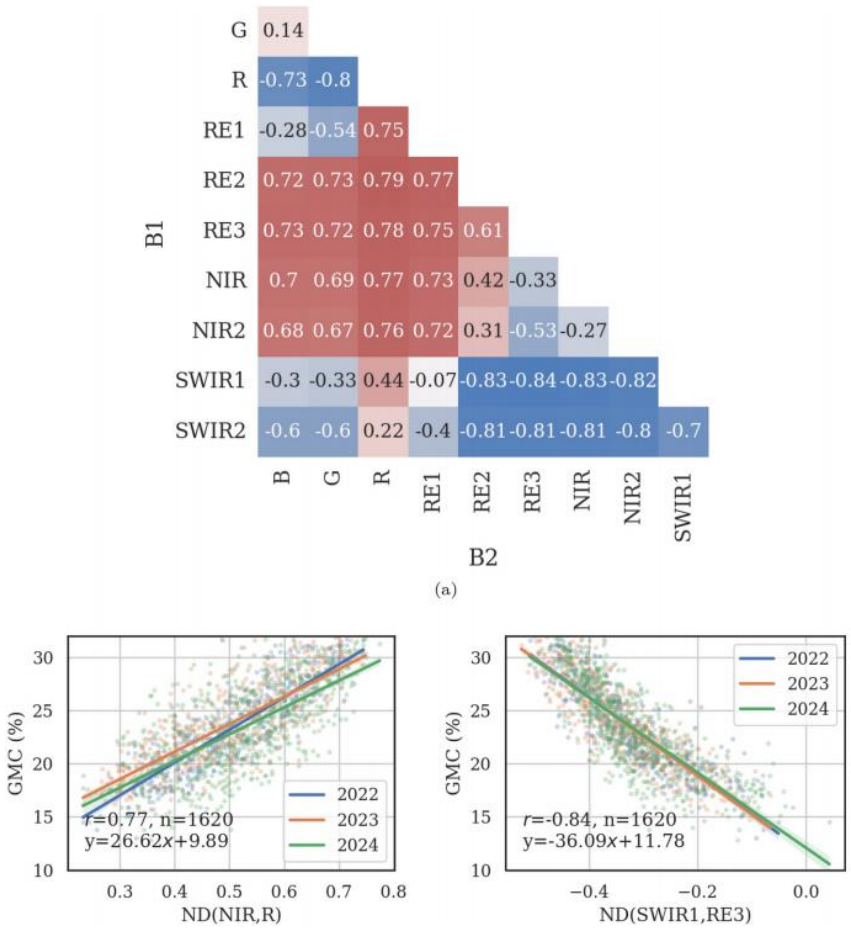

Figure 4 a Correlation coefficient between moisture and normalized difference spectral indices ND (B1,B2); b the relationship between NDVI=ND (NIR,R) and grain moisture content (GMC); c the relationship between most correlated index ND (SWIR1,RE3) and GMC (Adopted from Brinkhof et al., 2025)

5.2 Comprehensive evaluation method for optimal harvesting period

When determining the harvest time, focusing solely on a single indicator can often lead to a one-sided view. Therefore, it is necessary to consider all indicators together, such as the whole rice purity rate and taste performance. By integrating these indicators, for example, through a comprehensive scoring method, it becomes more convenient to compare the overall differences in different harvest periods (Zhou et al., 2025). This research was carried out along this line of thinking. From multiple harvest times, the one with the best overall performance was identified as the relatively suitable option (Zhang et al., 2024). In actual production, due to varying local conditions, adjustments to the weight of indicators can be made based on the target priorities. However, regardless of the changes, the prerequisite remains to stabilize the yield, and then through the comprehensive judgment of multiple indicators, find the harvest time with a more ideal quality performance.

5.3 The significance of harvest period optimization for coordinated improvement of rice quality

In the process of high-quality rice production, no matter how meticulous the management is in the early stage, if the harvest time is not well controlled, the effect can easily be weakened. If the harvest is not appropriate, not only will the appearance and taste of the rice be affected, but the yield and income may also decline (Zhou et al., 2025), as research shows that inappropriate harvest timing can significantly reduce yield and affect processing quality. In contrast, arranging the harvest period more reasonably can not only reduce unnecessary losses but also be more conducive to stabilizing the quality of rice, allowing consumers to buy and eat more satisfactory products (Mdpi et al., 2022), with studies indicating that optimizing harvest timing helps recover yield losses and improve output stability. From market demand to farmers' income, this link cannot be bypassed. For this reason, timely harvest, although seemingly ordinary, has always been a key task that cannot be ignored in high-quality rice production and is equally important for the long-term development of the industry.

6 Case Study: Comparative Analysis of Quality of a Dominant Rice Variety at Different Harvest Times

6.1 Experimental varieties, experimental design and harvest time settings

In the experiment, a high-quality japonica rice variety X that is widely used locally was selected. The focus was on the different arrangements of harvest times. Around the period before and after maturity, three situations were set up: early harvest, normal harvest, and delayed harvest. These roughly corresponded to harvesting about 7 days earlier, at the mature stage, and 7 to 10 days later. For each treatment, the moisture content of the grains was measured first, followed by drying and milling. Then, the whole-grain milling rate and taste-related indicators were analyzed, including the sensory performance of the rice and the content of amylopectin. By comparing these results together, the differences in quality changes under different harvest times were observed, thereby determining the impact of the harvest period on the quality of this variety, and providing a basis for determining a more appropriate harvest time (Teng et al., 2024). Related research on the effects of different harvest times on japonica rice quality properties—such as milling quality, appearance, and physicochemical traits—has been conducted using similar comparative harvest timing experiments (Zhou et al., 2025).

6.2 Measured results of moisture content, whole-grain rice yield ratio and flavor quality under different harvesting periods

When comparing the harvest times of several samples, the differences in quality are quite obvious. When the grains were harvested about 7 days in advance, the moisture content was still relatively high, with a moisture ratio close to 28%, and the whole grain milling rate was only about 60%. The cooked rice was hard and had a slight grassy flavor, and the overall taste was the worst. When the harvest was made at the mature stage, the situation was different. The moisture content dropped to around 22%, and the whole grain milling rate increased to the highest level, approximately 67% (Zhou et al., 2025). The rice was fragrant and soft, and the evaluation was the best. If the harvest was postponed further, the moisture content dropped to around 15%, and the whole grain milling rate and taste score started to decline again (MDPI et al., 2024). The rice became harder and the flavor became a little weaker. This change pattern is basically consistent with the existing research. For this variety, harvesting at the full maturity stage is more likely to balance both processing quality and taste performance.

6.3 Implications of the case results for production practice

When applied to actual production, this set of results is actually quite valuable. If the harvest is carried out too early, the grains have not fully matured, and usually the quality issues occur first. Such situations should be avoided as much as possible (Zhou et al., 2025). On the contrary, if the grains are harvested when they have just entered the complete ripening stage, the yield and quality can be better balanced. Generally, a moisture content of around 20% is considered appropriate. Of course, one cannot simply delay the harvest indefinitely. If the harvest is postponed, the amount of broken grains increases and the taste deteriorates, which is also not ideal (Teng et al., 2024). In practical operations, the harvest time cannot be uniformly applied by a fixed standard. It needs to be flexibly judged based on the specific characteristics of the variety and the weather conditions of the year. While ensuring the maturity, efforts should be made to avoid the decline in quality caused by either too early or too late harvesting.

7 Harvesting Period Control Suggestions in Production Practice

7.1 Principles for determining the appropriate harvesting time for rice in different ecological regions

The harvest times in different ecological zones cannot be uniformly standardized, but the underlying principles are similar. Generally speaking, when most of the rice grains in the fields have turned yellow and the proportion reaches or exceeds 90%, with the moisture content of the grains being around 20%, it is time to consider harvesting (Zhou et al., 2025). However, the specific operation methods depend on local conditions. In the southern rice-growing areas, one should pay more attention to typhoons and continuous rainy weather, and try to avoid these unfavorable conditions; in the northern rice-growing areas, it is more necessary to take preventive measures against the impact of the first frost (Teng et al., 2024). By considering these factors together and combining them with the characteristics of the varieties themselves to determine the harvest time, the rice can be harvested and stored at a relatively suitable state.

7.2 Optimization strategies for harvesting period under mechanized harvesting conditions

Under mechanized harvesting conditions, the harvesting time is often determined by the moisture content of the grains. Generally speaking, when the moisture level drops to around 16%, the operation of the combine harvester will proceed more smoothly; if the moisture is too high, there will be significant loss during threshing, and the cost of subsequent drying will also increase (Zhou et al., 2025). However, harvesting cannot be delayed indefinitely. If it is delayed for too long, the grains will become too dry and the fragmentation will be even more severe. During actual operation, one can first harvest the plots with slightly higher moisture content, and then wait for the moisture to naturally decrease in the remaining fields before concentrating on machine harvesting. A compromise can be made between efficiency and quality. At the same time, combined with timely drying, the rice should be quickly reduced to a safe moisture level to better stabilize the harvest quality (Teng et al., 2024).

7.3 The significance of harvest period management for the development of high-quality rice industry

In the production of high-quality rice, if the harvest time is properly managed, the results are often immediate. On one hand, the appearance and taste of the rice are more stable, making it easier for consumers to accept (Teng et al., 2024); on the other hand, it can also reduce the yield and quality losses caused by harvesting too early or too late, directly affecting farmers' income (Zhou et al., 2025). This seemingly simple arrangement of the harvest period actually runs through both the quality and efficiency aspects. Managing the harvest period well is an important foundation for promoting the sustained and healthy development of the high-quality rice industry.

8 Conclusion and Outlook

When all the results are considered together, it can be observed that the impact of harvest time on the quality of rice is always unavoidable. If the rice is harvested when the grain moisture content is close to 20%, the whole polished rice yield and the taste of the rice are often ideal; if it is harvested earlier or later, the performance in different aspects will be affected. Further comparison also shows that the relationship between moisture content, polished rice yield and taste is not isolated; relying on only one of these factors alone is difficult to determine the most suitable time. These phenomena in the experiment also once again confirm that if the harvest time is chosen appropriately, it is easier to take into account both the processing effect and the eating quality. This provides a relatively intuitive reference idea for how to scientifically arrange the harvest time in production.

Of course, this research also has its limitations. Due to the constraints of the conditions, the experiment only selected a few varieties and fixed locations. Under different rice varieties or ecological environments, the most suitable harvest time may not be completely consistent. The relevant conclusions need to be verified on a larger scale. Additionally, this study mainly focused on processing performance and flavor changes, and paid little attention to nutritional components and changes in quality during long-term storage. In the future, it is necessary to conduct related experiments in more varieties, different regions, and consecutive years, and combine with more precise detection methods to supplement and improve the existing conclusions.

From the perspective of subsequent research, there are still many areas that can be further improved regarding the issue of harvest time. There are significant differences among different varieties and different ecological regions, and it is difficult to solve this problem with a single standard. Therefore, it is necessary to conduct more experiments to gradually form more targeted regional guidance ideas. At the same time, if remote sensing or intelligent analysis methods can be combined, the maturity and water content changes of rice can be promptly monitored, and the judgment of harvest time will be more reliable. In production, the adjustment of harvest time cannot be advanced alone; it also needs to be coordinated with drying, storage and other processes to avoid excessive fluctuations in quality during subsequent processing. In breeding, it is also worth paying attention. Research on the adaptability of varieties should be strengthened, and new materials with more stable whole-grain rice yield and wider adaptability should be cultivated. The simultaneous efforts of research and promotion are necessary to make the optimization of harvest time truly implemented in production.

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Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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