

Identification and evaluation of rice quality traits in Southern Henan glutinous rice germplasm resources

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Abstract

Glutinous rice germplasm is abundant in Southern Henan and serves as a valuable genetic resource bank for the development of new glutinous rice cultivars. The identification and examination of rice quality traits in Southern Henan glutinous rice germplasm resources may provide a scientific foundation for the development and use of new, superior glutinous rice cultivars. Using a near-infrared grain analyzer in conjunction with biochemical and physical-chemical analysis techniques and methods, 13 representative glutinous rice varieties from the south of Henan Province were chosen as the experimental materials for this study. Their primary quality indexes, including appearance quality, milling quality, cooking and eating quality, and nutritional quality, were identified and categorized. The findings demonstrated that, with the exception of the three glutinous rice varieties Heixiangnuo 334, Xingengnuo 631, and Jugengnuo-GB-5, the chalkiness rate of 13 typical glutinous rice germplasm resources did not meet the national standard of good quality rice; Jugengnuo-GB-5, which is classified as first-class high-quality rice in the country, has the lowest gelatinization temperature. With the exception of Yanggengnuo 1, which had the highest taste value (92.23%) and Jugengnuo-GB-5, which had the lowest (34.86%); among the 13 glutinous rice varieties tested, the protein content was 9.09%; other glutinous rice varieties had less than 9.00%; the variation range was between 6.32% and 9.09%; and the content of free fatty acids varied among the varieties. Heixiangnuo 1926 had the highest free fatty acid content (31.66%), while Heixiangnuo 193 had the lowest (17.30%). In terms of milling quality, all glutinous rice varieties met the national standard for high-quality rice, with the exception of Heixiangnuo 334's brown rice rate and Heixiangnuo 193's whole milled rice rate. Yanggengnuo 1 performs better overall and has a greater rate of milled rice, entire milled rice, and taste value. The Southern Henan glutinous rice germplasm resources exhibit a wide range of variations in appearance quality, milling quality, cooking and eating quality, nutritional quality, and other key quality indices. These variations offer crucial information for the subsequent cultivation of new high-quality glutinous rice varieties.

Keywords: glutinous rice, quality traits, detection, Southern Henan, germplasm resources

1. Introduction

Half of the world's population depends on rice (*Oryza sativa* L.), making it one of the most significant food crops in the world [1]. Henan province is China's primary grain production base, and the country's rice planting area makes up 25% of the world's grain crop planted area. With 83% of the province's rice growing land, the Southern Henan region is Henan's primary rice-producing region [2]. Despite the abundance of glutinous rice genetic resources in Southern Henan, little research has been done on the quality of glutinous rice there, and it is still unknown how its important quality features are formed. Protein, fat, sugar, calcium, zinc, iron, vitamin B1 and B2, niacin, starch, and other components with high nutritional value may be found in glutinous rice [3]. The primary distinction between glutinous rice and other types of rice is its high amylopectin content, which is typically less than 2%. Because of its high viscosity, strong freezing-thawing properties, and limited coagulability, sticky rice starch is ideal for frozen food preparation and has a wide market potential [4]. As living conditions continue to rise, people's expectations for rice quality are rising along with their satisfaction with food and clothes. Customers in the market specifically choose premium glutinous rice [5]. In order to improve the rice quality of glutinous rice, it is therefore very important from a theoretical and commercial standpoint to identify and evaluate the rice quality characteristics of the glutinous rice germplasm resources in Southern Henan province and to investigate the high-quality glutinous rice germplasm resources. Although there are now several ways to classify glutinous rice, the two most often used types are indica and japonica glutinous rice. Because of their weak resilience to cold, Japonica types are often planted in high-altitude regions with low average temperatures. Because it prefers high temperatures, indica nuo is often grown in hilly or

subtropical plains [6]. Glutinous rice may be grown in the low-altitude, high-temperature, well-lit, and water-rich southern areas, where indica glutinous rice is mostly grown [7]. The Southern Henan region, which is situated near the Qinling Huai River, is in the transition zone from subtropical

zone to warm temperate zone, which is appropriate for both indica and japonica rice growth and production [8]. The quality features of glutinous rice, which are often classified into four areas both domestically and internationally: appearance quality, milling quality, cooking quality, and nutritional quality, vary depending on the climate [9]. The most significant aspect of appearance quality is the chalkiness character and grain type [10, 11]. The milling quality of rice is primarily determined by analyzing the brown rice rate, milled rice rate, and whole milled rice rate; the cooking taste quality is determined by the gelatinization temperature, amylose content, gum consistency, and taste value; and the nutritional quality is primarily determined by the protein content, free fatty acid content, amino acid content, and other rice character indexes. The qualitative characteristics of rice are affected differently by the climate in various places. While there is no link between daily average relative humidity and quality attributes and daily average precipitation, there is a significant correlation between daily average temperature and quality features. The impact of several climate-related ecological parameters on rice quality varies greatly [12]. In the province of Henan, Southern Henan is a significant rice-producing region where a sizable amount of indica rice is grown year-round. The yield, quality, disease resistance, and lodging resistance of ordinary farmed rice have all been extensively studied [13, 15], however there are no publications on the quality of glutinous rice germplasm resources in Southern Henan. In order to serve as a guide for the development of new, high-quality glutinous rice varieties in Southern Henan, this experiment tested and examined the appearance, grinding, cooking, and nutritional qualities of thirteen representative glutinous rice varieties in the region.

2. Materials and methods

2.1. Material

2.1.1. Test materials

There were 13 representative glutinous rice varieties in Southern Henan province, including 6 sweet glutinous rice varieties and 5 black glutinous rice varieties. The variety names and related information of glutinous rice are shown in table 1.

Table 1: The serial number and grain type of glutinous rice were tested

Number	Varieties	Grain length(mm)	Grain width(mm)	Aspect ratio
1	Xiangnuo 25 xuanzhan-1	7.53±0.13	3.18±0.05	2.37±0.07
2	Xiangnuo 25 xuanzhan-2	9.13±0.10	2.53±0.03	3.61±0.08
3	Heixiangnuo	6.69±0.12	3.67±0.18	1.82±0.07
4	Heixiangnuo 334	8.68±0.24	2.29±0.01	3.79±0.12
5	Heixiangnuo 1926	8.6±0.36	2.88±0.06	2.99±0.18
6	Yanggengnuo 1	7.23±0.12	3.44±0.05	2.10±0.04
7	Xingengnuo 631	6.67±0.07	3.14±0.08	2.12±0.05
8	Heifengnuo	9.43±0.45	2.63±0.06	3.59±0.25
9	Heixiangnuo 193	7.48±0.06	3.74±0.06	2.00±0.02
10	Jugengzhan-GB-6	6.50±0.11	3.04±0.05	2.14±0.05
11	Jugengzhan-GB-5	6.87±0.24	3.29±0.18	2.09±0.06
12	Jugengzhan-GB-19	7.93±0.10	2.7±0.05	2.94±0.07
13	PBM16	12.7±0.35	3.48±0.08	3.66±0.11

2.2. Field planting and management

According to the different growing period of glutinous rice germplasm resources, it will be planted in the same experimental field in Xinyang Normal University in 2019. Two rows were planted for each variety, with 12 plants in each row, and the plant and row spacing was 16.5 cm × 26.4 cm. *Waxy* rice variety test materials from sowing to the final seed maturity, the general field conventional cultivation and management, the whole growth period of the field to maintain shallow water, and strict control of diseases, insects, grass damage, harvest to maturity.

2.3. Preliminary treatment of test materials

After the glutinous rice germplasm resource material is mature, timely harvest, natural air drying, the use of a single plant thresher threshing processing, the glutinous rice germplasm resource material seeds placed at room temperature for 3 months, and then for the detection and analysis of quality traits.

3. Quality character determination

3.1. Determination of appearance quality

The traits measured for appearance quality included grain type (grain length, grain width and length-width ratio) and chalkiness (chalkiness rate, chalkiness size, chalkiness degree). Ten grains were randomly selected from the seeds of glutinous rice germplasm resources in Southern Henan province. The length of grains was measured with a scale after the first and the last were closely arranged.

The width of grains was measured with a scale after the first and last were closely arranged. According to the data of grain length and grain width, the ratio of length to width of each glutinous rice germplasm resource in Southern Henan was calculated. According to the national standard GB/t17891-1999, chalky characters were determined and analyzed: With ridge machine (JLG - II) will be selected to brown rice, glutinous rice seeds after grinding polishing machine (LTJM - 160 type) for milled rice. The fluorescent lamp was placed under the glass plate, and 200 full whole grains were randomly selected from the polished rice of each variety. The number of chalky grains was counted and repeated for 3 times. The average value was chalky rate; 10 grains of chalky rice were randomly selected from different waxy rice varieties and the percentage of chalky rice in the whole area was estimated. Chalkiness = chalkiness rate × chalkiness size. Finally, SPSS 20.0 was applied for statistical analysis of the measured data.

3.2. Determination of grinding quality

The processing quality of rice includes brown rice rate, milled rice rate and whole milled rice rate. Rice grinding and processing quality of glutinous rice germplasm resource was conducted in accordance with the standard NY 147-1988 issued by the ministry of agriculture [16].

3.3. Determination of cooking taste quality characteristics According to the cooking and eating quality of glutinous rice germplasm resources in Southern Henan, the gelatinization temperature and eating taste value were detected. The gelatinization temperature of 13 samples of glutinous rice germplasm resources in Southern Henan was determined according to the standard NY 147-1988 issued by the ministry of agriculture [16]. Taste value was detected by near-infrared grain analyzer [17, 26].

3.4. Determination of nutritional quality-related traits

In view of the nutritional quality of glutinous rice germplasm resources in Southern Henan, the contents of protein and free fatty acid in rice were mainly detected by using near-infrared grain analyzer [17,18,26].

4. Results and discussion

4.1. Detection and analysis of appearance quality

4.1.1. Detection of grain type of Southern Henan glutinous rice

Appearance quality is the most intuitive expression of rice quality, which directly affects the choice of consumers. Appearance quality mainly includes physical characteristics such as grain type and chalkiness. The grain type is mainly represented by grain length, grain width and aspect ratio. The International Rice Research Institute divides the rice grain length into four levels: super long (>7.50 mm), long (5.61-7.50 mm), medium (5.51-6.60 mm) and short (less than 5.50 mm). Using aspect ratio of whole rice to express grain shape, according to the International Rice Research Institute, the grain types are divided into four grades: slender (> 3.0), medium long (2.1-3.0), coarse (1.1-2.0) and round (< 1.0). Our country is divided into five levels: slender (> 3.0), long (2.5-3.0), medium long (2.0-2.5), short (1.0-2.0) and round (< 1.0) [19]. In this experiment, 13 representative waxy rice varieties were selected from the materials of waxy rice germplasm resources in Southern Henan. The results of grain type detection are shown in Table 1. In this experiment, the longest variety is PBM16, the grain length is 12.7 mm, the shortest is Jugengzhan-GB-6, the grain length is 6.50 mm, the average grain length is 8.11 mm; the widest variety is Heixiangnuo, the grain width is 3.67 mm, the narrowest is Heixiangnuo 334, the grain width is 2.29 mm, the average grain width was 3.08 mm; the largest variety was Heixiangnuo 334, the ratio of length to width was 3.79, the smallest variety was Heixiangnuo, the ratio of length to width was 1.82, and the average ratio of length to width of all seeds was 2.71. According to the International Rice Research Institute's classification standard of grain length, all the rice samples in this experiment belong to a long level, including 7 super long level glutinous rice varieties and 6 long level glutinous rice varieties. According to the classification standards of grain types in China, among the 13 varieties of glutinous rice in this experiment, 4 belong to the slender level, 2 belong to the long level, 6 belong to the medium long level, and 1 belongs to the short level (Table 1).

4.1.2. Detection of Chalkiness in Southern Henan glutinous rice varieties

5. One of the key indicators of rice's visual quality is its chalkiness. Chalkiness degree and chalkiness rate are the two primary indicators used to quantify it [20]. The national standard GB/T 17891-1999 [20] divides high-quality rice into three grades based on the difference between chalkiness rate and degree: first-class high-quality rice has a chalkiness rate of no more than 10.0% and a chalkiness degree of no more than 1.0%; second-class high-quality rice has a chalkiness rate of no more than 20.0% and a chalkiness degree of no more than 30.0% and a chalkiness degree is no more than 5.0%. The quality of rice's look improves with decreasing chalkiness rate and degree. Four of the thirteen waxy rice germplasm resources in Southern Henan had deeper colors, making it impossible to determine the chalkiness size. Figure 1 displays the findings of the other nine kinds' chalkiness character detection: Heixiangnuo 334 had no discernible chalkiness, whereas Heixiangnuo 1926 had a 100% chalkiness rate. Xiangnuo 25 xuanzhan-2 and Heixiangnuo 193 are classified as grade III high quality rice, Xingengnuo 631 and Jugengzhan-GB-5 as grade II high quality rice, and Heixiangnuo 334 as grade I high quality rice in accordance with the national standard GB/T 17891-1999 for high quality rice. The other four varieties—Heixiangnuo 1926, Heifengnuo, Jugengzhan-GB-6, and Jugengzhan-GB-19—have sizable chalky patches that fall short of China's high-quality rice

standards; in other words, there are notable variations in the chalky characteristics of waxy rice germplasm resources in Southern Henan.

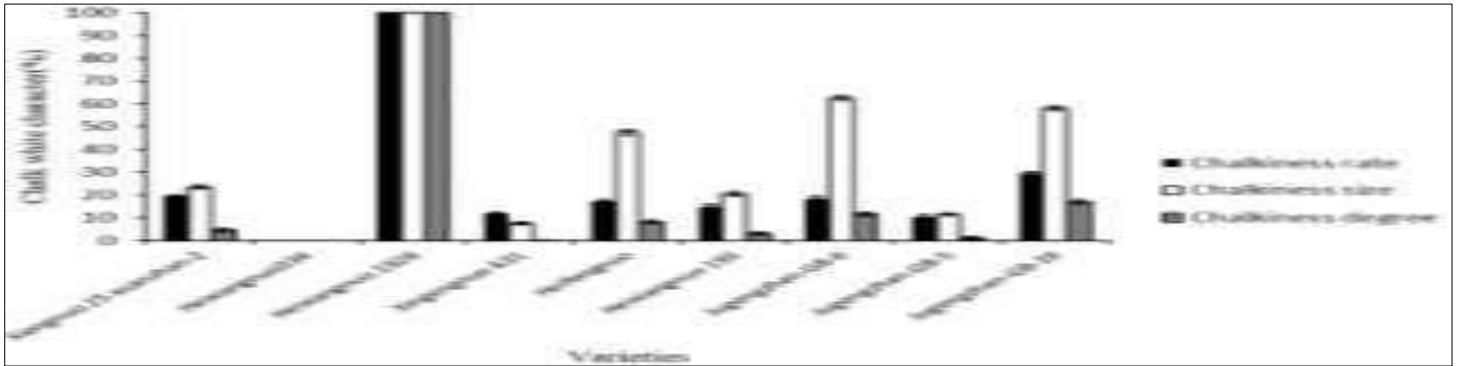


Fig 1: Detection of chalkiness characters of Southern Henan glutinous rice varieties

5.1. Inspection of grinding quality

The milling quality of rice mainly includes brown rice rate, milled rice rate and head milled rice rate. Brown rice rate is the percentage of brown rice weight to rice weight, milled rice rate is the percentage of milled rice weight to rice weight, head milled rice rate is the percentage of milled rice weight to rice weight. The processing quality of different varieties is different, in which the brown rice rate is generally 77%~84%, the milled rice rate is 67%~74%, and the head milled rice rate is 20%~70% [21]. In this experiment, 13 brown rice germplasm materials in Henan Province were selected, the brown rice rate was between 72%~83%, the milled rice rate was 63%~76%, and the head milled rice rate was between 43%~71% (Fig. 2). Among them, the highest brown rice rate is Heixiangnuo 193 (82.07%), the lowest is Heixiangnuo 334 (72.00%); the highest milled rice rate is Yanggengnuo 1 (75.35%), the lowest is Heixiangnuo 193 (63.94%); the highest head milled rice rate is Yanggengnuo 1 (70.19%), the lowest is PBM16 (43.55%). The above results showed that there were rich variations in the rice processing quality of waxy rice germplasm resources in Southern Henan, which provided important information for the selection of new varieties with good processing quality in later stage.

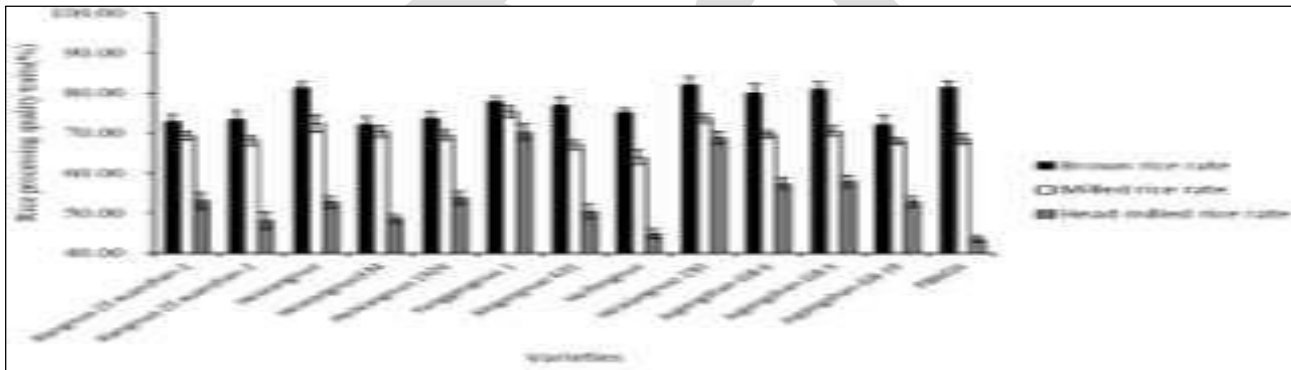


Fig 2: Inspection of processing quality of Southern Henan glutinous rice varieties

5.2. Detection and analysis of cooking and eating quality related characters

5.2.1. Detection of gelatinization temperature of Southern Henan glutinous rice varieties

6. The gelatinization temperature, which ranges from 50 to 80 degrees Celsius, is crucial to the cooking and consumption quality of rice. In breeding and processing, it is often classified into three groups: low (< 70 degrees Celsius), medium (70–74 degrees Celsius), and high (> 74 degrees Celsius). The physical properties of rice cooking are determined by the gelatinization temperature. Alkali extinction value is often employed to indirectly express gelatinization temperature due to the strong association between the two variables and the comparatively simple technique of calculation [22]. Low gelatinization temperatures are indicated by an alkali extinction value of 6-7, medium gelatinization temperatures by a value of 4-5, and high gelatinization temperatures by a value of 1-3. High-quality rice must have a low gelatinization temperature (the first-class high-quality rice alkali elimination value is 6-7) [21]. Only three waxy rice varieties had alkali elimination values lower than grade 3, while the majority of the waxy rice germplasm resources in the southern region of Henan had alkali elimination values greater than grade 4 (Table 2). Three varieties of Xiangnuo 25 xuanzhan-2, Heixiangnuo 1926, and Jugengzhan-GB-5 have high gelatinization temperatures, four varieties of Xingengnuo 631, Heixiangnuo 193, Jugengzhan-GB-6, and PBM16

have low gelatinization temperatures, and the remaining varieties have medium gelatinization temperatures, according to the classification standard. Jugengzhan-GB-5 has the lowest alkali dissipation value (grade 2), which has a greater gelatinization temperature, whereas Jugengzhan-GB-6 has the greatest alkali dissipation value (grade 6.5), which corresponds to grade I high-quality rice. As a result, the identification and examination of the gelatinization temperature in Southern Henan glutinous rice germplasm offers a crucial point of reference for genetic breeding and the enhancement of Southern Henan glutinous rice's cooking and consumption quality.

Table 2: Gelatinization temperature detection of Southern Henan glutinous rice varieties

Number	Varieties	Alkali Value	Pasting Temperature Range (°C)	Type
1	Xiangnuo 25 xuanzhan-1	5.33±0.52	70~74	Medium gelatinization temperature
2	Xiangnuo 25 xuanzhan-2	2.83±0.75	>74	High gelatinization temperature
3	Heixiangnuo	4.00±0.00	70~74	Medium gelatinization temperature
4	Heixiangnuo 334	4.67±1.51	70~74	Medium gelatinization temperature
5	Heixiangnuo 1926	2.83±0.41	>74	High gelatinization temperature
6	Yanggengnuo 1	4.67±0.82	70~74	Medium gelatinization temperature
7	Xingengnuo 631	5.50±0.55	<70	Low gelatinization temperature
8	Heifengnuo	5.17±1.33	70~74	Medium gelatinization temperature
9	Heixiangnuo 193	6.17±0.41	<70	Low gelatinization temperature
10	Jugengzhan-GB-6	6.50±0.55	<70	Low gelatinization temperature
11	Jugengzhan-GB-5	2.00±0.00	>74	High gelatinization temperature
12	Jugengzhan-GB-19	4.50±0.55	70~74	Medium gelatinization temperature
13	PBM16	5.67±0.82	<70	Low gelatinization temperature

4.3.2 Detection of taste value of glutinous rice varieties in Southern Henan

The taste value of rice is a comprehensive index, which is closely related to the appearance quality, cooking taste quality and physical and chemical properties [23], it determines the cooking taste quality of rice, the higher the taste value, the better the taste of rice. By comparing 13 samples of *glutinous* rice germplasm resources in Southern Henan province, the food taste value of brown rice was detected, it was found that Xiangnuo 25 xuanzhan-2 had the highest taste value (78.77%), next is Heixiangnuo (78.53%), Heixiangnuo 1926 (34.56%) and Xiangnuo 25 xuanzhan-1 (12.48%) have low taste values (Fig. 3), so have poor taste. By comparing the taste value test results of glutinous rice germplasm resources in Southern Henan, it was found that Yanggengnuo 1 had the highest taste value (92.23%) and the best taste; Heixiangnuo 193 (32.04%) and Jugengzhan-GB-5 (34.86%) with low taste value and poor taste.

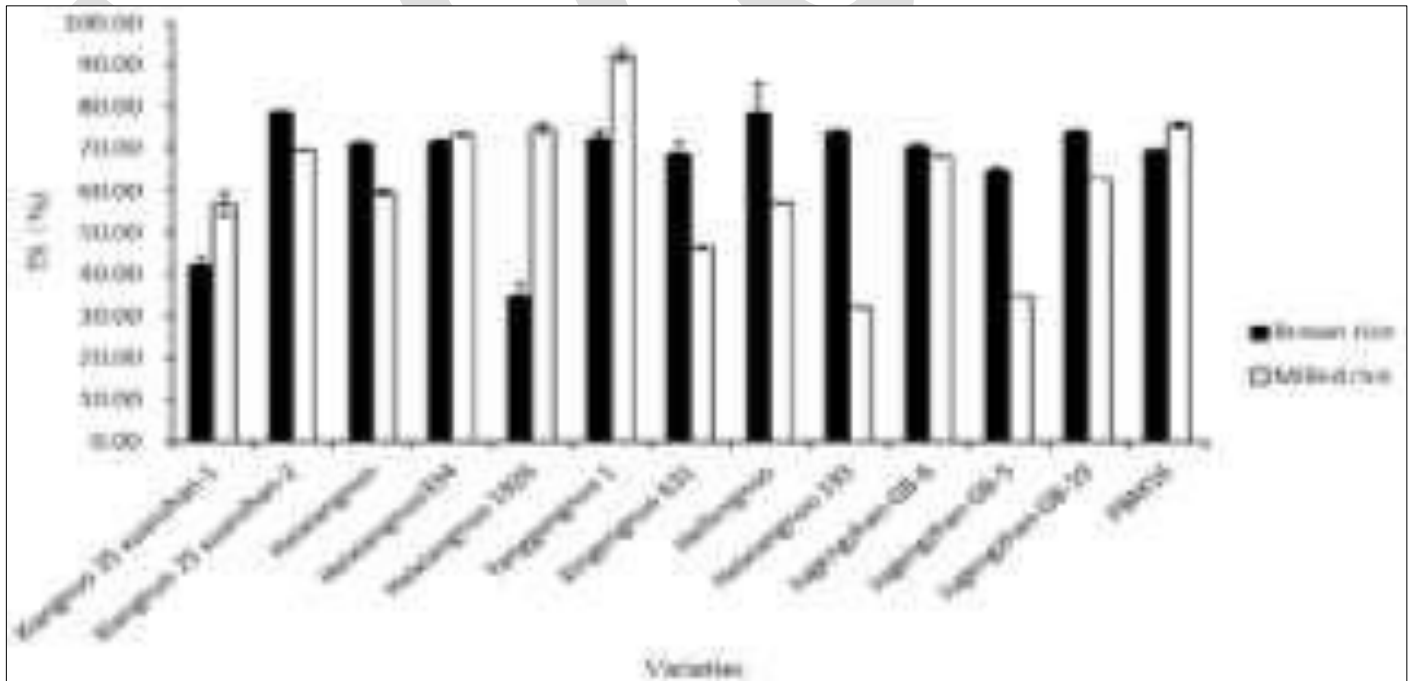


Fig 3: The taste value of brown rice and milled rice of glutinous rice in Southern Henan

4.4 Detection and analysis of nutritional quality related traits

4.4.1 Determination of free fatty acid content in brown rice of glutinous rice in Southern Henan

The fat content in rice is the main factor affecting the taste of rice. The higher the content of free fatty acid, the better the rice luster and the higher the nutritional value [24]. Among the *glutinous* rice germplasm resources in Southern Henan, Heixiangnuo 1926 (31.66%) had the highest free fatty acid content, followed by Xiangnuo 25 xuanzhan-1 (30.16%), and Heixiangnuo 193 (17.30%) had the lowest free fatty acid content, 14.36% difference with Heixiangnuo 1926 (Fig. 4). It can be seen that the content of free fatty acids in the glutinous rice germplasm resources in Southern Henan differs greatly, which provides an important reference for the selection of new glutinous rice varieties with high nutritional quality in the future.

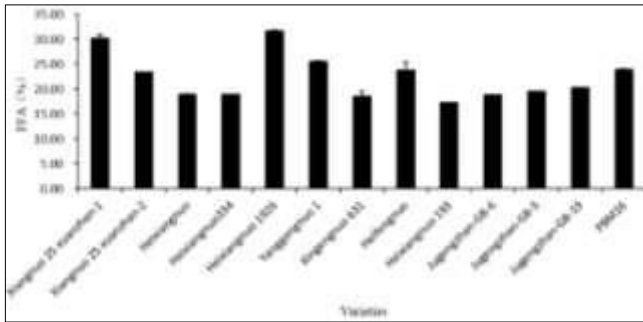


Fig 4: The test results of the content of free fatty acids (FFA) in brown rice of glutinous rice of Southern Henan

4.4.2 Detection of protein content in brown rice and milled rice of glutinous rice in Southern Henan

5 One significant aspect of rice's nutritional quality is its protein content. Rice protein level varies between 5.1% and 15.4% in brown rice and 4.5% and 14.3% in milled rice, according to studies [22]. The protein content of 13 samples of glutinous rice in Southern Henan ranged from 8.11% to 12.88%, with the difference between maximum and minimum content being 4.77%. Among the milled rice varieties of glutinous rice in Southern Henan, Yanggengnuo 1 (9.09%) had the highest protein content, followed by Heixiangnuo 1926 (8.56%) and Heixiangnuo (6.32%) had the lowest protein content, according to the results of the near-infrared grain analyzer. There was a 2.77% difference between the greatest and lowest protein content of Southern Henan's glutinous rice, which ranged from 6.32% to 9.09%. The protein content of glutinous rice in Southern Henan varies less than that of brown rice, and milled rice typically has a lower protein content than brown rice (Fig. 5). This provides some insight for the later selection and breeding of new glutinous rice varieties with high nutritional quality.

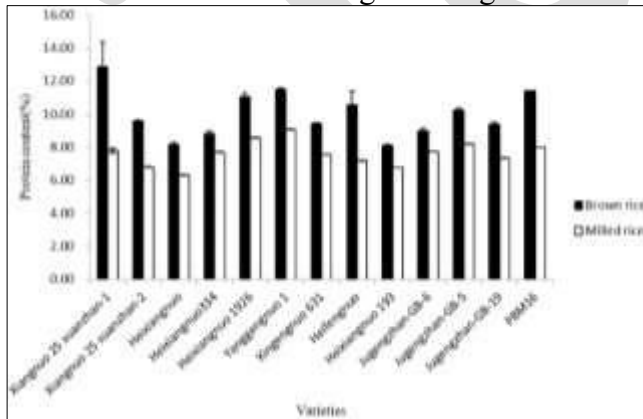


Fig 5: Detection results of protein content in brown rice and milled rice of glutinous rice in Southern Henan

7. Discussion

8. The four primary categories of rice quality are appearance, milling, cooking and eating, and nutritional. The most significant aspect of rice's look is its chalkiness, which includes its degree, size, and pace. In addition to being a crucial indicator of rice's visual quality, chalkiness also affects the rice's quality when it comes to cooking, eating, milling, processing, and even lowering rice yield [25–27]. Chalkiness is a common quantitative feature that is readily influenced by the external environment and regulated by many quantitative trait loci. Thirteen waxy rice germplasm resources in Southern Henan had greater rates, sizes, and degrees of chalkiness. Heixiangnuo 334 is

classified as first-class high-quality rice, whereas Xinjingnuo631 and Jujingzhan-GB-5 are classified as second-class high-quality rice. Other rice varieties fall short of the high-quality rice criterion. This might be connected to the environment in Southern Henan, where high temperatures, high humidity, and hot summer rains all contribute to the development of chalkiness in glutinous rice seeds. The fact that all of the rice evaluated in this experiment had grain lengths in the long grade, which is part of the long and thin grade as well as the medium and long grade, is very intriguing since it offers useful breeding material for the development of new, superior glutinous rice types. We can evaluate the quality of rice grinding by measuring the brown rice rate, the milled rice rate, and the entire milled rice rate. The test findings of 13 glutinous rice germplasm resources in Southern Henan show that, with the exception of Heixiangnuo 334's brown rice rate and Heixiangnuo 193's whole milled rice rate, which are somewhat below the normal range, the other types satisfy the standard. Among them, Yangjingnuo 1 has a high percentage of whole and milled rice, as well as a good taste value, indicating a high breeding value. The quality of cooking and eating is what most people care about. The physical properties of rice cooking are determined by the gelatinization temperature. When rice with a high gelatinization temperature is overcooked, it spreads easily and doesn't form. It will need more water and time than rice with a low gelatinization temperature if it is not cooked using the basic technique [28]. To enhance the cooking and eating quality of rice, it is crucial to grow and develop types with low gelatinization temperatures. The other types had low to medium gelatinization temperatures, with just three (Xiangnuo25, Xuanzhan-2, Heixiangnuo 1926, and Jujingzhan-GB-5) having high gelatinization temperatures. Jujingzhan-GB-5, which is classified as first-grade high-quality rice, has the greatest alkali elimination value (6.5 grade) among them. Rice's flavor is influenced by a variety of characteristics, including its protein content and alkali digestion value [29, 30]. In Southern Henan glutinous rice germplasm resources, Yangjingnuo 1 had the greatest flavor value (92.23%) while Jujing-GB-5 had the lowest taste value (34.86%). Thirteen Southern Henan glutinous rice types exhibited various, diversified, and higher taste values, all of which suggested that the rice tasted better. Protein is one of the most vital nutrients and a significant source of protein for human intake among the numerous nutrients found in rice that are good for the human body [29]. Rice typically has a protein concentration of approximately 8%, which is rather low when compared to other crops. Varieties that have more over 9% protein often taste bad [31]. In Southern Henan, the protein content of milled rice from waxy rice germplasm resources ranged from 6.32% to 9.09% (Fig. 5). Studying the amount of free fatty acids in rice is crucial since humans cannot produce free fatty acids on their own and must get them from diet. The shine of rice increases with its free fatty acid concentration [24]. Heixiangnuo 1926 (31.66%) had the greatest free fatty acid content among the germplasm resources in Southern Henan, whereas Heixiangnuo 193 (17.30%) had the lowest. As a result, South Henan's rice germplasm materials have a wide range of nutritional quality characteristics, which provide valuable breeding resources for the development of novel glutinous rice types with excellent nutritional quality.

9. Conclusion

The main quality indices of the tested materials, such as appearance quality, milling quality, cooking and eating quality, and nutritional quality, were found to be rich in variation through the detection and analysis of the rice quality characters of Southern Henan glutinous rice germplasm resources. This provided valuable breeding materials for the subsequent selection of new high-quality glutinous rice varieties in Southern Henan.

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