



Detection and analysis of rice quality characters in Southern Henan glutinous rice germplasm resources

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Abstract

Southern Henan is rich in germplasm resources of glutinous rice, which is an important genetic resource bank for breeding new varieties of glutinous rice. The detection and analysis of rice quality characters in Southern Henan glutinous rice germplasm resources can provide scientific basis for the breeding and application of new high-quality glutinous rice varieties. In this study, 13 representative glutinous rice varieties in the south of Henan Province were selected as the experimental materials, and their main quality indexes, such as appearance quality, milling quality, cooking and eating quality, and nutritional quality, were detected and classified by using near-infrared grain analyzer combined with biochemical and physical-chemical analysis techniques and methods Analysis. The results showed that the chalkiness rate of 13 typical glutinous rice germplasm resources was not up to the national standard of high quality rice, except for the three glutinous rice varieties of Heixiangnuo 334, Xingengnuo 631 and Jugengnuo-GB-5; In terms of gelatinization temperature, the gelatinization temperature of Jugengnuo-GB-5 was the lowest, which belongs to the national first-class high-quality rice. Except that the alkali dissipation value of three glutinous rice varieties is less than 3 (high gelatinization temperature), other glutinous rice varieties are all of medium low gelatinization temperature; In terms of taste value, among the 13 glutinous rice varieties tested, Yanggengnuo 1 had the highest (92.23%) and Jugengnuo-GB-5 had the lowest (34.86%); Among the 13 glutinous rice varieties tested, except Yanggengnuo 1, the protein content was 9.09%, other glutinous rice varieties were less than 9.00%, and the variation range was between 6.32% to 9.09%; The content of free fatty acids was different among the varieties. The highest content was Heixiangnuo 1926, its free fatty acid content was 31.66%, the lowest content was Heixiangnuo 193, which was 17.30%; As for the milling quality, except the brown rice rate of Heixiangnuo 334 and the whole milled rice rate of Heixiangnuo 193, the processing quality of other glutinous rice varieties all reached the national standard of high quality rice. Among them, Yanggengnuo 1 has higher milled rice rate, whole milled rice rate and taste value, and the overall performance is better. There are abundant variations in appearance quality, milling quality, cooking and eating quality, nutritional quality and other main quality indexes of Southern Henan glutinous rice germplasm resources, which provide important information for the cultivation of new high-quality glutinous rice varieties in the later stage.

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

1. Introduction

Rice (*Oryza sativa* L.) is one of the most important food crops in the world, with half of the world's population living on rice [1]. China's rice planting area accounts for one quarter of the world's grain crop sown area, and Henan province is the main grain production base in China. The Southern Henan region is the main rice producing area in Henan, accounting for 83% of the province's rice planting area [2]. Although glutinous rice germplasm resources are abundant in Southern Henan, there are few studies on rice quality of *glutinous* rice in Southern Henan, and the formation mechanism of its key quality traits is still unclear. Glutinous rice contains protein, fat, sugar, calcium, zinc, iron, vitamin B₁, vitamin B₂, niacin, starch and other nutrients with high nutritional value [3]. The biggest difference between glutinous rice and other kinds of rice is that it contains high levels of amylopectin, which is generally less than 2%. The starch of *glutinous* rice has the characteristics of high viscosity, good freezing-thawing property and weak coagulability, so it is very suitable for making frozen food and has a broad market prospect [4]. With the steady improvement of people's living standards, people are not only satisfied with food and clothing, but also have

higher and higher requirements on the quality of rice. In particular, high-quality glutinous rice is favored by consumers in the market [5]. Therefore, it is of great theoretical significance and broad market prospect to detect and analyze the rice quality traits of glutinous rice germplasm resources in Southern Henan province, and to explore the high-quality glutinous rice germplasm resources, so as to improve the rice quality of glutinous rice.

At present, there are many classification methods for glutinous rice, but generally accepted classification methods are divided into two categories, namely indica glutinous rice and japonica glutinous rice. Japonica varieties have poor cold resistance and are mostly planted in areas with high altitude and low average temperature. Indica nuo likes high temperature and is often cultivated in subtropical plains or hilly areas [6]. The southern regions with low altitude, good light conditions, high temperature and abundant water resources are favorable for the cultivation of glutinous rice, and the southern regions mainly plant *indica* glutinous rice [7]. Located in the Qinling Huai river area, the Southern Henan region is in the transition zone from subtropical

zone to warm temperate zone, which is suitable for the cultivation and production of rice and suitable for *indica* and *japonica* [8]. Different climate characteristics have different effects on the quality traits of glutinous rice, which are generally divided into four categories at home and abroad, namely appearance quality, milling quality, cooking quality and nutritional quality [9]. Appearance quality mainly includes chalkiness character and grain type, of which chalkiness is the most important appearance quality character [10, 11]; The milling quality of rice mainly analyzed the brown rice rate, milled rice rate and the whole milled rice rate; Cooking taste quality includes gelatinization temperature, amylose content, gum consistency and taste value; Nutritional quality mainly includes protein content, free fatty acid content, amino acid content and other character indexes of rice. The climate in different areas has different effects on the quality traits of rice. The correlation coefficient between daily average temperature and quality traits is large, while the correlation coefficient between daily average precipitation and daily average relative humidity and quality traits is small. The effect of different climate ecological factors on rice quality is significantly different [12]. Southern Henan is a major rice producing area in Henan province, where a large area of *indica* rice is cultivated all the year round. There have been a lot of studies on the yield, quality, disease resistance and lodging resistance of common cultivated rice [13, 15], but no reports on the rice quality of glutinous rice germplasm resources in Southern Henan. In this experiment, the appearance quality, grinding quality, cooking quality and nutritional quality of 13 representative glutinous rice varieties in Southern Henan were tested and analyzed, in order to provide reference for the cultivation of new glutinous rice varieties with high quality in Southern Henan.

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 g

ermplasm 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 m 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

The chalkiness of rice is one of the important indexes reflecting the appearance quality of rice. It is mainly measured by two indexes: chalkiness rate and chalkiness degree^[20]. According to the national standard GB/T 17891-1999^[20], high quality rice is divided into three grades according to the difference of chalkiness rate and chalkiness degree: the first-class high-quality rice with the chalkiness rate not higher than 10.0% and the chalkiness degree not higher than 1.0%; the second-class high-quality rice with the chalkiness rate not higher than 20.0% and the chalkiness degree not higher than 3.0%; the third-class high-quality rice with the chalkiness rate not

Higher than 30.0% and the chalkiness degree not higher than 5.0%. The smaller the chalkiness rate and chalkiness degree, the better the appearance quality of rice. Among the 13 waxy rice germplasm resources in Southern Henan, 4 were darker in color, so the chalkiness size could not be observed. The results of chalkiness character detection of the other 9 varieties are shown in Fig. 1: No significant chalkiness was observed in Heixiangnuo 334, the chalkiness rate of heixiangnuo 1926 was 100%. According to the classification of national standard GB/T 17891-1999 for high quality rice, Xiangnuo 25 xuanzhan-2 and Heixiangnuo 193 belong to grade III high quality rice, Xingengnuo 631 and Jugengzhan-GB-5 belong to grade II high quality rice, and Heixiangnuo 334 belongs to grade I high quality rice. The other four varieties, Heixiangnuo 1926, Heifengnuo, Jugengzhan-GB-6 and Jugengzhan-GB-19, have large chalky areas, which are not up to the standard of high-quality rice in China, that is to say, there are significant differences in chalky characters of waxy rice germplasm resources in Southern Henan.

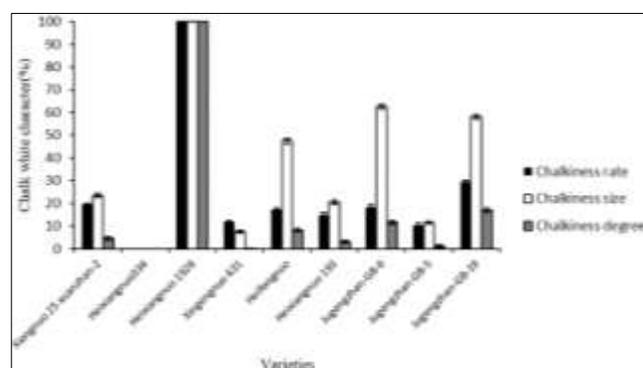


Fig 1: Detection of chalkiness characters of Southern Henan glutinous rice varieties

4.2. 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.

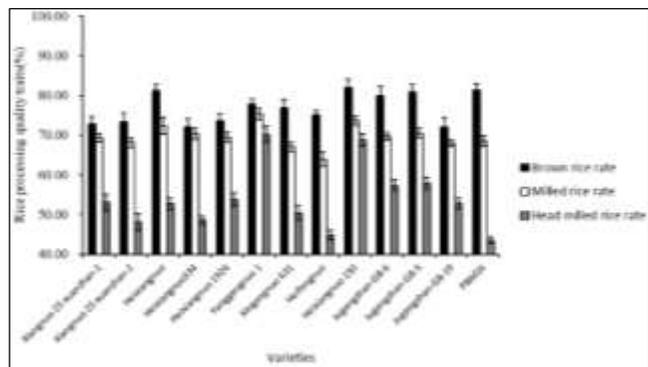


Fig 2: Inspection of processing quality of Southern Henan glutinous rice varieties

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

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

The gelatinization temperature plays an important role in the cooking and eating quality of rice, it varies from 50 °C to 80 °C, in breeding and processing, it is usually divided into three categories: low (< 70 °C), medium (70-74 °C) and high (> 74 °C). Gelatinization temperature determines the physical cooking characteristics of rice. Because of the high correlation between alkali extinction value and gelatinization temperature, and the

relatively easy determination method, alkali extinction value is usually used to indirectly express gelatinization temperature [22]. The alkali extinction value of grade 6-7 corresponds to low gelatinization temperature, grade 4-5 corresponds to medium gelatinization temperature, and grade 1-3 corresponds to high gelatinization temperature. Low gelatinization temperature is required for high-quality rice (the first-class high-quality rice alkali elimination value is 6-7) [21]. In the materials of waxy rice germplasm resources in the Southern of Henan, most of the alkali elimination values were higher than grade 4, and only three waxy rice varieties had alkali elimination values lower than grade 3 (Table 2). According to the classification standard of gelatinization temperature, it is concluded that: Xiangnuo 25 xuanzhan-2, Heixiangnuo 1926, Jugengzhan-GB-5, three varieties are high gelatinization temperature; Xingengnuo 631, Heixiangnuo 193, Jugengzhan-GB-6 and PBM16, four varieties are low gelatinization temperature; the rest are medium gelatinization temperature. Among them, Jugengzhan-GB-6 has the highest alkali dissipation value (grade 6.5), which belongs to grade I high-quality rice, Jugengzhan-GB-5 has the lowest alkali dissipation value (grade 2), which has higher gelatinization temperature. Therefore, the detection and analysis of gelatinization temperature in Southern Henan rice germplasm provides an important reference for the genetic breeding and quality improvement of cooking and eating quality of Southern Henan glutinous rice.

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.

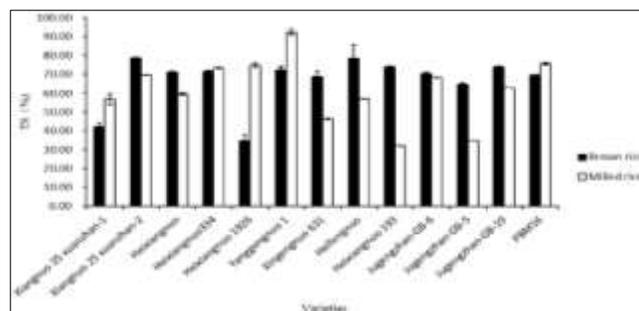


Fig 3: The taste value of brown rice and milled rice of glutinous rice in Southern Henan

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.

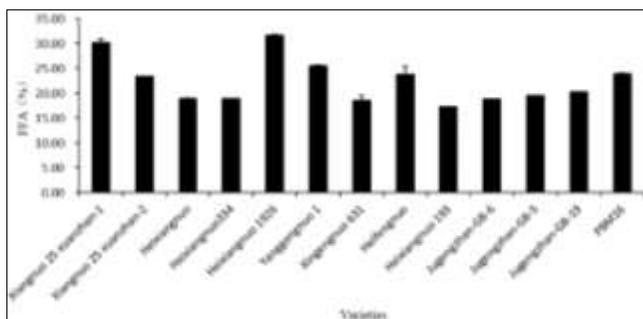


Fig 4: The test results of the content of free fatty acids (FFA) in brown rice of glutinous rice of Southern Henan

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

The protein content of rice is an important shape of nutritional quality. Studies have shown that the variation range of rice protein content in brown rice and milled rice is 5.1%~15.4% and 4.5%~14.3%, respectively [22]. The results of near-infrared grain analyzer showed that Xiangnuo 25 xuanzhan-1 (12.88%) had the highest protein content in brown rice, Yanggengnuo 1 (11.51%) was the next highest in protein content, Heixiangnuo 193 (8.11%) had the lowest protein content, the protein content of 13 samples of glutinous rice in Southern Henan ranged from 8.11% to 12.88%, the difference between maximum and minimum content was 4.77%; Among the milled rice varieties of glutinous rice in Southern Henan, the protein content of Yanggengnuo 1 (9.09%) was the highest, followed by that of Heixiangnuo 1926 (8.56%), and that of Heixiangnuo (6.32%) was the lowest. The protein content of glutinous rice in Southern Henan varied from 6.32% to 9.09%, with a difference of 2.77% between the highest and lowest content. Compared with the protein content of brown rice, the protein content of glutinous rice in Southern Henan has a relatively small variation range, and milled rice tends to have a lower protein content than brown rice (Fig. 5), which has certain enlightenment for the selection and breeding of new glutinous rice varieties with high nutritional quality in the later period.

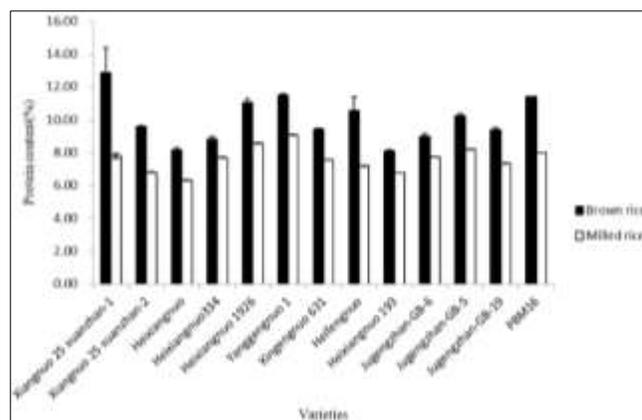


Fig 5: Detection results of protein content in brown rice and milled rice of glutinous rice in Southern Henan

5. Discussion

Rice quality is mainly divided into appearance quality, milling quality, cooking and eating quality and nutritional quality. Chalkiness is the most important appearance quality character in rice, including chalkiness rate, chalkiness size and chalkiness degree. Chalkiness is not only the key factor to measure the appearance quality of rice, but also has an important impact on the cooking and eating quality, milling and processing quality of rice, and even leads to the reduction of rice yield [25-27]. Chalkiness is a typical quantitative trait, which is controlled by multiple quantitative trait loci and easily affected by the external environment. The chalkiness rate, chalkiness size and chalkiness degree of 13 waxy rice germplasm resources in Southern Henan were higher. Xinjingnuo631 and Jujingzhan-GB-5 belong to the second-class high-quality rice, Heixiangnuo 334 belongs to the first-class high-quality rice, and other varieties of rice do not meet the standard of high-quality rice. This may be related to the climate in the Southern Henan: the summer rainfall is hot in the same season, the humidity is high, and the temperature is high, which may be conducive to the generation of Chalkiness in the seeds of glutinous rice. It is very interesting that the grain length of all the tested rice in this experiment belongs to the long grade, which belongs to the long and thin grade and the middle and long grade, which provides valuable breeding materials for the breeding of new high-quality glutinous rice varieties.

By testing the brown rice rate, the milled rice rate and the whole milled rice rate, we can analyze the grinding quality of rice. According to the test results of 13 glutinous rice germplasm resources in Southern Henan, it can be found that except the brown rice rate of Heixiangnuo 334 and the whole milled rice rate of Heixiangnuo 193 are slightly lower than the normal range, other varieties meet the standard. Among them, Yangjingnuo 1 has a high rate of milled rice and whole milled rice, and its taste value is also high, which shows that it has a high breeding value. Cooking and eating quality is the quality that people are generally concerned about. The gelatinization temperature determines the physical cooking characteristics of rice.

If the rice with high gelatinization temperature is over cooked, it is easy to spread and not form. If the rice with general method is not cooked, it will take more water and time than the rice with low gelatinization temperature [28]. Therefore, it is very important to cultivate and introduce varieties with low gelatinization temperature to improve the cooking and eating quality of rice. Only three varieties (Xiangnuo25, Xuanzhan-2, Heixiangnuo 1926, Jujingzhan-GB-5) were high gelatinization temperature, and the rest were low to medium gelatinization temperature. Among them, the alkali elimination value of Jujingzhan-GB-5 is the highest, which is 6.5 grade, belonging to the first-grade high-quality rice. There are many factors that affect the rice taste value, protein content and alkali digestion value will affect its taste value [29, 30]. By comparing the taste value of brown rice in Southern Henan glutinous rice germplasm resources, Yangjingnuo 1 had the highest taste value (92.23%), and Jujing-GB-5 (34.86%) with low taste value. The taste value of 13 Southern Henan glutinous rice varieties were different, varied and had higher taste value, which indicated that the taste of rice was better.

Rice contains many nutrients which are beneficial to human body, among which protein is one of the most important nutrients and an important source of protein for human consumption [29]. Compared with other crops, the protein content of rice is relatively low, generally about 8%. Varieties with more than 9% protein content tend to have poor taste and taste [31]. The protein content of milled rice of waxy rice germplasm resources in Southern Henan varied from 6.32% to 9.09% (Fig. 5). Because human beings cannot synthesize free fatty acids by themselves, they can only get them from food, so it is very important to study the content of free fatty acids in rice. The higher the content of free fatty acid in rice, the better the luster of rice [24]. Among the materials of germplasm resources in Southern Henan, the content of free fatty acids in Heixiangnuo 1926 (31.66%) was the highest, and that in Heixiangnuo 193 (17.30%) was the lowest. Therefore, there are abundant variations in the nutritional quality characters of rice germplasm materials in South Henan, which provide important breeding resources for the breeding of new high nutritional quality glutinous rice varieties.

6. Conclusion

Through the detection and analysis of the rice quality characters of Southern Henan glutinous rice germplasm resources, it was found that the main quality indexes of the tested materials, such as appearance quality, milling quality, cooking and eating quality, and nutritional quality, were rich in variation, which provided valuable breeding materials for the later selection of new high-quality glutinous rice varieties in Southern Henan.

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