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Detection and Analysis of Rice Quality of Yunnan Purple Rice Seed Resources

Bo Peng[1, *], Jing Qiu[1], Ziyi Xue[1], Shuang Tu[1], Anqi Lou[1], Chao Dong[2], Cuifeng Tang[2], Xinxiang A[2, *], Fang Yang[3], Yanming Zhang[3], Mengyang Zheng[1], Yaqin Huang[4], Yanyang Sun[1], Quanxiu Wang[1], Wei Zhou[1], Hongyu Yuan[1, *]

[1]College of Life Sciences and Institute for Conservation and Utilization of Agro-bioresources in Dabie Mountains, Xinyang Normal University, Xinyang, China

[2]Biotechnology and Germplasm Resources Institute, Scientific Observation Station for Rice Resource of Yunnan, Ministry of Agriculture and Rural Affairs, Yunnan Academy of Agricultural Sciences Kunming, Kunming, China

[3]State Key Laboratory of Hybrid Rice, College of Life Sciences, Wuhan University, Wuhan, China

[4]College of Biological and Pharmaceutical Engineering, Xinyang Agriculture and Forestry University, Xinyang, China

Email address:

pengbo@xynu.edu.cn (Bo Peng), ahope2002@163.com (Xinxiang A), yhongyu92@163.com (Hongyu Yuan)

[*]Corresponding author

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Abstract: Purple rice, as a special rice with important nutritional and health functions, has important scientific significance and application value for genetic improvement of purple rice and breeding of new varieties through in-depth study on its grain quality characters. In this paper, the grain quality characters of 39 kinds of purple rice introduced from Yunnan were tested, and the test results were analyzed comprehensively, which provided scientific basis for the introduction and popularization of high quality purple rice in Yunnan. Taking purple rice germplasm resources introduced from Yunnan Province as experimental materials, the appearance quality, cooking and eating quality, cooking and eating quality of 39 kinds of purple rice were analyzed by using near-infrared grain analyzer, automatic amino acid analyzer, viscometer and microwave digestion instrument combined with biochemical and physical-chemical analysis techniques and methods the grinding quality and nutritional quality were detected and analyzed. The results showed that there were abundant variation types in grain length, grain width, ratio of length to width, gelatinization temperature, taste value, amylose content, viscosity of rice flour, protein content, amino acid content, brown rice rate, milled rice rate and head rice rate. In particular, the appearance quality of grain type, milling quality of head rice rate, nutritional quality of amino acid content, cooking and eating quality of Rice Flour Viscosity, eating value and gelatinization temperature and other important quality traits in rice materials have a wide range of variation. Therefore, the results of this study provide important genetic and breeding resources for the breeding of new rice varieties with high quality.

Keywords: Purple Rice, Rice Quality, Detection, Analysis, Yunnan

1. Introduction

Rice (*Oryza sativa* L.) is one of the most important food crops in the world. More than half of the world's population lives on rice, and nearly two thirds of China's population lives on rice [1-2]. Yunnan is a large agricultural province, and rice is the main crop in Yunnan, which produces 40% of the total grain yield with a quarter of the cultivated land area [3]. Colored rice widely exists in the ancestral wild rice. Because colored rice is linked with shattering and low germination rate, it is eliminated in production. White rice is select as the main cultivated rice [4]. With the improvement of people's living standards, the demand for high-quality rice is increasing [5]. Compared with ordinary rice, colored rice contains more protein and trace elements, and has higher nutritional value than white rice. Purple rice is an ancient rice

variety in China. It has a long planting history and many varieties, which has high economic value. Anthocyanin accumulation in the inner flower of rice seed coat led to purple rice [6-7]. Anthocyanins have the functions of antioxidation and free radical scavenging, reducing the activity of enzymes, anti-mutation and other health functions, and can replace benzoic acid in food to synthesize preservatives, as nutritional enhancers and food colorants. Yunnan is the region with the richest biodiversity in the world and one of the centers with the largest genetic and ecological diversity of rice species in the world. It is rich in purple rice resources [8-10]. The quality characters of some purple rice varieties were detected and compared, which is of great significance for the introduction, popularization and application of high quality purple rice in Yunnan, and even for the overall improvement of the quality of purple rice.

Since the 1950s, on the whole, the rice planting area in Yunnan has been in a steady growth trend, basically maintaining the scale of 100.00-1133300 hm^2 [11]. From 2006 to 2015, Yunnan Province adhered to the market orientation in rice production, adjusted the rice variety structure, and shifted the focus of rice production from the single pursuit of quantity to the direction of both quantity and quality [11]. The development of purple rice industry is highly valued. But it is undeniable that there are still some problems in the development of purple rice industry, such as low popularity, small planting scale and few processing enterprises. Generally, rice quality is divided into four categories in China: appearance quality, milling quality, cooking and eating quality and nutritional quality [12-13]. The nutritional quality of colored rice depends on the content of protein, amino acids and vitamins [14]. Purple rice is a kind of pigment rice. It contains water-soluble purple pigment in rice husk, glume and leaf. Purple rice pigment is a compound flavonoid compound composed of anthocyanins and Malva anthocyanins. It has attracted much attention due to its functions of changing enzyme activity, improving microcirculation, improving immunity, anti-oxidation and anti-aging [15-16]. The main index to measure the milling quality of rice is head rice rate. The higher the head rice rate is, the better the milling quality is. The cooking and eating quality of rice is mainly measured by gelatinization temperature, gel consistency and amylose content. At the same time, the viscosity of rice flour is also an important index reflecting its cooking and eating quality [17-18]. Cooking and eating quality and appearance quality of rice are the most important quality traits and evaluation indicators [19], and also the two rice quality traits most concerned by consumers.

Purple rice is an unique and precious rice in Yunnan. In addition to the concentrated distribution in Yunnan, it also has a certain distribution in Shaanxi, Sichuan, Guizhou, Guangdong, Guangxi and other provinces in China [20]. At present, the research on purple rice mainly focuses on the genetics of purple seed coat [21], and the research on its rice quality is relatively rare. At the same time, rice quality is a complex quantitative trait, which is easily affected by different environmental conditions [22-24]. From the collected varieties of Yunnan black purple rice, we determined their morphological characteristics, milling quality and cooking and eating quality from the aspects of rice quality.

In this study, the morphological characteristics, cooking and eating quality, processing and grinding quality of Yunnan purple rice variety resources were determined to provide the basis for breeding and development of Yunnan Purple Rice Variety Resources.

2. Materials and Methods

2.1. Materials

2.1.1. Experimental Materials

Thirty nine purple rice varieties were introduced and applied in Yunnan Province.

Table 1. *Varieties of Purple rice.*

Number	Variety name	Variety source	Number	Variety name	Variety source
1	Purple glutinous rice	Menghai	21	Zinuo 8	Mojiangxian
2	Jiegunuo 1	Menghai	22	Zigu 3	Mojiangxian
3	Haokandou	Menghai	23	Xiangzinuo 1	Xishuangbannazhou
4	Shangyongzinuo	Mengla	24	Xiangzinuo 2	Xishuangbannazhou
5	Zinuo 1	Mengla	25	Hanzinuo (007)	Xishuangbannazhou
6	Zigu 1	Menghai	26	Zimi 1	Xishuangbannazhou
7	Heinuomi 1	Menghai	27	Zigu 4	Xishuangbannazhou
8	Haobixiang	Luxi	28	Zinuo 9	Xishuangbannazhou
9	Haobixiangnong	Luxi	29	Heinuo	Yunxian
10	Zinuo 2	Ximeng	30	Zinuo 10	Lvchunxian
11	Zinuo 3	Menglianxian	31	Zimi 2	Lvchunxian
12	Xiaoheinuo	Jiangcheng	32	Zigu 5	Honghexian
13	Zinuo 4	Changyuan	33	Heijienuo	Shuangbaixian
14	Jiegunuo 2	Jiangchengxian	34	Zimi 3	Shuangbaixian
15	Zinuo 5	Menglianxian	35	Daheinuo	Longyangxian
16	Heinuomi 2	Menghai	36	Heinuogu 1	Changningxian
17	Zinuo 6	Zhengyaunxian	37	Heinuogu 2	Changningxian
18	Zinuo 7	Zhenyuanxian	38	Jixuenuo	Tengchongxian
19	Zinuo (1)	Mojiangxian	39	Zinuo 11	Xinpingxian
20	Zigu 2	Mojiangxian			

2.1.2. Field Planting and Management

39 purple rice varieties were sown in the same field. Each variety was planted in 2 rows with 12 plants in each row, and the spacing between plants and rows was 16.5 cm × 26.4 cm. From sowing to the final seed maturity, the materials were cultivated and managed in common field. During the whole growth period, the shallow water layer was kept in the field, and the diseases, insects and weeds were strictly controlled.

2.1.3. Pretreatment of Experimental Materials

After harvest, the seeds were naturally dried and threshed by 5ts-150a single plant thresher. The seeds were stored at room temperature for 3 months, and then their quality characters were detected.

2.1.4. Determination of Rice Quality

The physical and chemical indexes for evaluating rice quality at home and abroad are basically the same, generally including appearance quality, nutritional quality, milling quality and cooking and eating quality of rice [25].

2.2. Detection Methods of Rice Quality

2.2.1. Determination of Cooking and Eating Quality

The cooking and eating quality of rice is mainly measured by gelatinization temperature, gel consistency and amylose content, and the viscosity of rice flour is also an index of cooking and eating quality. The gelatinization temperature and gel consistency of rice were tested according to the standard NY 147-1988 issued by the Ministry of agriculture [20]. The gelatinization temperature of rice is generally 55 ~ 79°C, which is one of the important indexes to determine the quality of rice [26, 27]. Amylose content was detected by near infrared grain analyzer [6, 16]. If the amylose content is too low, the rice will be soft, sticky and greasy, with poor elasticity [28]. The viscosity of rice was determined by U.S. Bolefeld Viscometer (ku-3 model) repeated three times, and the average value was the corresponding viscosity value.

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2.2.2. Determination of Main Appearance Quality

10 seeds were randomly selected from 39 groups of samples, and their length and width were measured. The average value was obtained as the grain length and width. The measurement was repeated three times, and the ratio of grain length and width was calculated. Because the aleurone layer of purple rice seeds was purple, the chalkiness of grains could not be detected effectively, so only the grain type characters were investigated.

2.2.3. Determination of Main Nutritional Quality

The content of protein and amino acid in rice plays a decisive role in the nutritional quality of rice. Near infrared grain analyzer was used to detect the protein content in rice [6, 16]. The milled rice of Japonica rice was ground into rice flour by whirlwind mill. 0.2 g of rice flour was sent to the bottom of hydrolysis tube and 10 ml of 6 mol × After the hydrolysis, it was cooled and shaken to a constant volume, and then deacidified and concentrated on the vacuum deacidification instrument, then the content of amino acids in the tested rice flour was determined and analyzed by automatic amino acid analyzer [6, 22].

Table 2. *Operation mode of microwave digestion instrument.*

Temperature (°C)	Pressure (Pa)	Time (min)
100	10	1
110	20	3
140	30	10

2.2.4. Determination of Grinding Quality

The milling quality of Japonica rice was mainly composed of brown rice rate, milled rice rate and head rice rate. The milling quality of Japonica rice was tested according to the standard NY 147-1988 issued by the Ministry of agriculture [20].

Table 3. *Analysis results of appearance quality of purple rice (unit: mm).*

Variety	Grain length (mm)	Grain width (mm)	Length-width ratio	Variety	Grain length (mm)	Grain width (mm)	Length-width ratio
Zinuodao	1.03±0.05	0.25±0.03	4.07±0.69	Zinuo 8	9.07±0.13	2.83±0.31	3.20±0.40
Jiegunuo 1	9.28±0.11	3.39±0.03	2.74±0.02	Zigu 3	8.83±0.05	2.82±0.06	3.13±0.08
Haokandou	9.49±0.02	3.51±0.02	2.70±0.01	Xiangzinuo 1	8.69±0.08	2.80±0.04	3.10±0.03
Shangyongzinuo	9.49±0.02	3.82±0.07	2.48±0.05	Xiangzinuo 2	8.54±0.24	2.88±0.12	2.96±0.05
Zinuo 1	8.95±0.37	3.30±0.09	2.71±0.17	Hanzinuo (007)	9.16±0.06	2.57±0.04	3.56±0.04
Zigu 1	9.38±0.14	2.85±0.05	3.29±0.02	Zimi 1	8.54±0.03	3.01±0.09	2.84±0.07
Heinuomi 1	9.59±0.14	2.62±0.10	3.66±0.10	Zigu 4	9.29±0.36	3.40±0.50	2.74±0.38
Haobixiang	9.55±0.07	3.22±0.02	2.96±0.05	Zinuo 9	8.31±0.10	3.09±0.12	2.69±0.11
Haobixiangnong	9.30±0.21	2.51±0.02	3.71±0.10	Heinuo	7.86±0.03	3.03±0.03	2.59±0.03
Zinuo 2	8.78±0.11	2.51±0.03	3.50±0.01	Zinuo 10	8.84±0.07	3.11±0.04	2.84±0.04
Zinuo 3	8.50±0.01	8.50±0.00	1.00±0.00	Zimi 2	8.86±0.09	3.23±0.06	2.74±0.04

Variety	Grain length (mm)	Grain width (mm)	Length-width ratio	Variety	Grain length (mm)	Grain width (mm)	Length-width ratio
Xiaoheinuo	9.85±0.10	3.11±0.16	3.16±0.13	Zigu 5	9.63±0.13	3.06±0.11	3.14±0.10
Zinuo 4	10.51±0.02	3.19±0.08	3.30±0.08	Heijienuo	9.53±0.12	2.82±0.16	3.38±0.24
Jiegunuo 2	9.67±0.04	2.95±0.06	3.28±0.05	Zimi 3	7.89±0.16	3.20±0.13	2.47±0.49
Zinuo 5	9.28±0.07	3.22±0.02	2.88±0.05	Daheinuo	8.70±0.02	3.39±0.02	2.57±0.02
Heinuomi 2	8.13±0.12	3.26±0.07	2.49±0.08	Heinuogu 1	9.29±0.16	3.24±0.06	2.87±0.07
Zinuo 6	8.97±0.07	3.40±0.01	2.63±0.02	Heinuogu 2	9.51±0.11	3.46±0.06	2.75±0.04
Zinuo 7	8.83±0.07	3.50±0.10	2.52±0.09	Jixuenuo	9.10±0.33	3.04±0.05	2.99±0.11
Zinuo (1)	8.79±0.03	3.46±0.06	2.54±0.03	Zinuo 11	10.25±0.25	3.23±0.06	3.17±0.10
Zigu 2	8.75±0.05	3.2±0.02	2.73±0.03				

3. Results and Analysis

3.1. Detection and Analysis of the Particle Type

From the results of quality traits test of Yunnan Purple Rice, it can be found that there are obvious differences in seed length, seed width and length width ratio of different purple rice germplasm materials (Table 3). Among the 39 purple rice varieties tested, the grain length of Zinuo 4 was the longest (10.51 mm). The grain length of black glutinous was the shortest (7.86mm), The grain width of purple glutinous rice was the narrowest (0.25 mm). The grain width of Zinuo 3 was the widest (8.50 mm)； The length width ratio of purple glutinous rice was the highest (4.07 mm) The length width ratio of purple Nuo 3 was the smallest, only 1.00 (Table 3). The grain type of 39 Yunnan Purple Rice Germplasm resources was mainly slender, with an average length width ratio of 2.93mm. Therefore, there are abundant variations in the grain types of Purple Rice Germplasm Resources in Yunnan, which provide important resources for the breeding of new slender Purple Rice Varieties with high quality in the future.

3.2. Test results of Cooking and Eating Quality

3.2.1. Detection and Analysis of Gelatinization Temperature

Gelatinization temperature plays an important role in the cooking and eating quality of rice. It determines the physical cooking characteristics of rice, which is usually expressed by alkali dissipation value. Among the 39 purple rice samples tested, heinuo had the lowest alkali dissipation value of 1.7, and the highest alkali- dissipation value of 7.0, which was zigu 5, heijienuo and jixuenuo. The results showed that low gelatinization temperature was the most, accounting for 40.15% of the total, followed by medium gelatinization temperature, accounting for 30.77%, and high gelatinization temperature was the least, accounting for 23.08%. Therefore, the above experimental data showed that there was a large variation range of gelatinization temperature in Yunnan Purple Rice Germplasm resources, which provided important genetic resources for the cultivation and popularization of new varieties of Yunnan Purple Rice.

Table 4. *Test results of gelatinization temperature of rice.*

Variety	Alkaline elimination value	Gelatinization temperature range (°C)	Type	Variety	Alkaline elimination value	Gelatinization temperature range (°C)	Type
Zinuodao	2.3 level	>74	High gelatinization temperature	Zinuo 8	4.3 level	70~74	Midium gelatinization temperature
Jiegunuo 1	4.5 level	70~74	Midium gelatinization temperature	Zigu 3	6.2 level	<70	Low gelatinization temperature
Haokandou	2.3 level	>74	High gelatinization temperature	Xiangzinuo 1	3.0 level	>74	High gelatinization temperature
Shangyongzinuo	4.7 level	70~74	Midium gelatinization temperature	Xiangzinuo 2	6.0 level	<70	Low gelatinization temperature
Zinuo 1	5.6 level	<70	Low gelatinization temperature	Hanzinuo (007)	3.0 level	>74	High gelatinization temperature
Zigu 1	3.0 level	>74	High gelatinization temperature	Zimi 1	6.5 level	<70	Low gelatinization temperature
Heinuomi 1	6.0 level	<70	Low gelatinization temperature	Zigu 4	6.0 level	<70	Low gelatinization temperature
Haobixiang	5.2 level	<70	Low gelatinization temperature	Zinuo 9	3.3 level	70~74	Midium gelatinization temperature
Haobixiangnong	6.0 level	<70	Low gelatinization temperature	Heinuo	1.7 level	>74	High gelatinization temperature
Zinuo 2	6.0 level	<70	Low gelatinization temperature	Zinuo 10	6.2 level	<70	Low gelatinization temperature
Zinuo 3	4.0 level	70~74	Midium gelatinization temperature	Zimi 2	6.4 level	<70	Low gelatinization temperature
Xiaoheinuo	4.0 level	70~74	Midium gelatinization temperature	Zigu 5	7.0 level	<70	Low gelatinization temperature

Variety	Alkaline elimination value	Gelatinization temperature range (°C)	Type	Variety	Alkaline elimination value	Gelatinization temperature range (°C)	Type
Zinuo 4	4.0 level	70~74	Midium gelatinization temperature	Heijienuo	7.0 level	<70	Low gelatinization temperature
Jiegunuo 2	3.0 level	>74	High gelatinization temperature	Zimi 3	2.5 level	>74	Low gelatinization temperature
Zinuo 5	5.0 level	70~74	Midium gelatinization temperature	Daheinuo	6.0 level	<70	Low gelatinization temperature
Heinuomi 2	5.0 level	70~74	Midium gelatinization temperature	Heinuogu 1	3.0 level	>74	High gelatinization temperature
Zinuo 6	5.2 level	<70	Low gelatinization temperature	Heinuogu 2	3.8 level	70~74	Midium gelatinization temperature
Zinuo 7	3.5 level	70~74	Midium gelatinization temperature	Jixuenuo	7.0 level	<70	Low gelatinization temperature
Zinuo (1)	2.7 level	>74	High gelatinization temperature	Zinuo 11	4.7 level	70~74	Midium gelatinization temperature
Zigu 2	6.0 level	<70	Low gelatinization temperature				

3.2.2. Detection and Analysis of Taste Value

The milling quality of Japonica rice was mainly composed of brown rice rate, milled rice rate and head rice rate. The milling quality of Japonica rice was tested according to the standard NY 147-1988 issued by the Ministry of agriculture [20]. The taste value of rice is an important factor to determine whether rice varieties can occupy the market for a long time. The eating value of milled rice varied greatly, but the range was between 60 and 100. Among them, the taste value of millibroom was the highest (98.0), followed by mouse-2 (96.6), the taste values of Manyougu and Haoannong were lower (60.9 and 60.0), respectively, the taste values of Dahangu, Haosa, Xigu, Babaoxiang, Baiyouzi and Yunhui 290 were all above 90, the taste values of Ximaxiangu, Haobawan, Haobierao, Haojinga, Baimazhagu, Laomiangu, Laozhaigu and Thai soft rice were all above 90 Below 70, this provides an important basis for the later rice promotion.

Table 5. *Determination results of palatable value of milled rice.*

Variety	Teste value	Variety	Teste value	Variety	Teste value
Ximaxiangu	66.4±5.9	Xigu	92.8±1.2	Baimazhagu	67.0±7.2
Maxiangu	74.2±1.9	Haoanwang	83.4±1.4	Baiyouzhi	90.7±3.1
Dahangu	94.1±2.3	Haoandian	82.1±3.5	Bendiyouzhi	82.6±2.1
Haosa	93.2±0.5	Haoanlang	86.7±1.0	Huangbansuo	89.5±2.5
Haobawan	65.4±3.3	Haoannong	60.0±8.9	Laomiangu	60.2±1.2
Haozhou	98.0±1.7	Haoannonghuomen	77.3±0.3	Laomianxianggu	72.7±2.2
Bigu	83.1±7.3	Haobierao	65.6±0.5	Laozhaigu	60.4±0.5
Fanhaopi	84.3±2.6	Haojinge	61.7±0.3	Manyougu	60.9±0.5
Haobihuang	80.5±0.9	Haomenlia	75.5±1.6	Menglaixianggu	77.0±1.1
Haonaihuang	81.9±2.0	Jiangdongdabaigu	79.4±2.1	Qiguizao	79.0±9.8
Haogaogongcheng	77.5±1.7	Baxidabaigu	87.4±2.2	Taiguoruanmi	65.6±1.0
Haogaogongwei	75.4±0.8	Xiaobaigu	78.3±0.3	Tianza 58	82.6±2.0
Haohaonen	72.9±1.7	Ruanbaigu	74.7±0.4	Gengnong	70.4±3.9
Haomuxi	87.5±1.7	Babaogu	85.0±3.6	9311	70.4±3.4
Haomulei	84.5±3.8	Babaoxiang	93.7±1.2	Laoshuya-2	96.6±9.9
Chugeng 27	78.1±0.8	Xiaoxianggu	61.4±0.2	Yungeng 37	71.7±3.6
Hexi 41	78.5±1.1	Diantun 502	79.0±6.4	Yungeng 290	93.8±1.1
Haopi	71.8±0.5				

3.2.3. Detection and Analysis of Amylose Content

The amylose content has an important influence on the milling and processing quality, cooking and eating quality and nutritional quality of rice. The rice with high amylose content is harder and the rice grains are more shiny. Rice with high amylose content will have lower viscosity, higher elasticity and not easy to chew, so rice with lower amylose content is favored by consumers. Among them, the test results in polished rice showed that the amylose content of Haoannong was the highest, which was 42.44%, the content of Manyougu was the lowest, which was 2.12%. This provides an important basis for the later in-depth study of various qualities of rice.

Table 6. *Detection results of amylose content in milled rice.*

Number	Amylose content (%)	Number	Amylose content (%)	Number	Amylose content (%)	Number	Amylose content (%)
Xixianmagu	30.32±1.35	Haogaogongcheng	22.82±0.19	Haobierao	17.20±0.32	Laomianxianggu	24.51±0.89
Maxiangu	21.27±0.30	Haogaogongcheng	19.57±0.21	Haojinge	30.56±0.02	Laozhaigu	15.35±0.15
Dahangu	18.98±0.31	Haohaonen	22.41±0.19	Haomenlia	19.61±0.33	Manyougu	2.12±0.25
Haosa	19.57±0.73	Kufagu (4)	23.67±0.60	Jiangdongdabaogu	18.89±0.69	Menglaixiangmi	19.13±0.20
Haobawan	42.09±0.26	Haomuxi	21.73±0.63	Baxidabaigu	19.30±0.41	Qiguizao	34.41±7.80
Haobawan	34.28±1.16	Haomuxi	13.08±0.38	Xiaobaigu	19.10±0.15	Taiguoruanmi	26.98±0.17
Haobawan	26.30±0.64	Haomuxi	18.63±0.25	Ruanbaigu	27.09±0.21	Tianza 58	24.73±0.81
Haobawan	36.81±0.46	Haomuxi	15.64±0.61	Babaogu	18.65±2.45	Gengnong	29.85±1.30
Haobawan	29.62±0.19	Haomulei	21.54±0.65	Babaoxiang	16.22±0.40	9311	29.51±0.51
Haozhou	11.85±0.44	Xigu	6.35±0.25	Xiaoxianggu	7.28±0.24	Laoshuya-2	32.12±1.83
Haobi	26.01±0.68	Haoanwang	17.38±0.39	Baimazhagu	31.29±1.89	Yungeng 37	29.55±1.02
Haobi	24.79±1.30	Haoandian	23.38±1.17	Baiyouzhi	13.79±0.61	Yunhui 290	16.83±0.53
Fanhaopi	24.40±1.05	Haoanlang	13.69±0.09	Bendiyouzhi	15.86±0.56	Zhentun 502	27.42±0.72
Haobihuang	24.15±0.22	Haoannong	42.44±6.04	Huangbansuo	18.63±0.73	Chugeng 27	25.85±0.34
Haonaihuang	21.90±1.64	Haoannonghuomen	18.97±0.18	Laomiangu	30.22±0.39	Hexi 41	15.30±0.42
Haobi	12.47±0.19						

3.2.4. Detection and Analysis of Rice Noodle Viscosity

The cooking and eating quality of rice is mainly measured by the three character indicators of gelatinization temperature, gel consistency and amylose content, and the viscosity of rice noodles is also an indicator of its cooking and eating quality. The viscosity of rice was measured by the American Brookfield Viscometer (KU-3 model), repeated 3 times, and the average value is the corresponding viscosity value。In the whole process of simulating rice cooking, when the rice noodles are heated to 50°C for the first time, the viscosity of various rice noodles are different. Among them, the viscosity of Yunjing 37 is 33.3cp at the minimum, while the viscosity of Xiangnuogu is 272.3cp at the maximum, When the temperature is heated from 50°C to 95°C, the viscosity of the rice noodles increases, but the viscosity of Tianza 58 (2324.7cp) increases significantly while the viscosity of Diantun 502 (292.0cp) increases the least, When the temperature is cooled to 50°C again, the viscosity of Tianza 58 (3913.3cp) increases again and the increase is most obvious. At the same time, the viscosity of some varieties appears to decrease, for example: the viscosity of the millipede (661.0cp) decreases more obviously. In the whole process of simulating rice cooking, when the rice noodles are heated to 50°C for the first time, the viscosity of various rice noodles are different. Among them, the viscosity of Yunjing 37 is 33.3cp at the minimum, while the viscosity of Xiangnuogu is 272.3cp at the maximum, When the temperature is heated from 50°C to 95°C, the viscosity of the rice noodles increases, but the viscosity of Tianza 58 (2324.7cp) increases significantly while the viscosity of Diantun 502 (292.0cp) increases the least, When the temperature is cooled to 50°C again, the viscosity of Tianza 58 (3913.3cp) increases again and the increase is most obvious. At the same time, the viscosity of some varieties appears to decrease, for example: the viscosity of the millipede (661.0cp) decreases more obviously.

Table 7. *Viscosity test results of kinds of rice flour.*

Variety	Rise to 50°C	Rise to 95°C	Fall to 50°C	Variety	Rise to 50°C	Rise to 95°C	Fall to 50°C
Yunjing 37	33.3±5.1	775.7±8.6	1444.7±7.8	Haobawan	43.0±9.5	1444.3±6.9	2112.3±1.3
Yunhui 290	123.3±5.6	1828.3±8.3	1606.7±5.6	Haogaogongcheng	79.3±9.8	1384.0±5.0	1956.0±2.4
Diantun 502	69.3±7.8	292.0±3.3	326.7±9.6	Xiaobaigu	49.3±3.0	556.0±6.1	356.0±5.5
Chujing 27	68.3±3.8	1731.3±8.9	2730.0±7.4	Ruanbaigu	41.0±5.0	1094.0±5.0	3280.7±1.6
Haopi	49.3±1.6	1632.3±6.9	1688.9±7.3	Babaogu	54.3±4.3	1341.3±6.3	1795.3±3.3
Danuo	71.0±8.4	1533.0±5.9	1766.0±7.4	Xiaoxiangdu	62.7±5.7	1936.3±6.3	2044.3±1.3
Xiannuogu	272.3±6.4	1839.7±8.1	1615.0±3.3	Baimazhagu	43.0±3.0	1298.7±7.7	1643.0±8.0
Haojiehai	59.3±8.9	1572.7±7.7	2730.0±8.2	Baiyouzhi	64.3±3.3	1547.3±6.7	2457.3±2.1
Babaomi	51.4±3.1	1637.5±5.2	2171.7±6.6	Bendiyouzhi	43.0±3.0	1008.7±3.7	1522.0±5.0
Haoannong	47.7±7.8	1753.0±7.9	1821.7±8.3	Laomiangu	43.0±3.0	1161.0±7.0	1313.3±1.7
Haoanwangmierao	64.3±6.9	1914.7±5.1	2415.0±4.7	Laozhaigu	77.7±3.3	1328.3±3.3	2079.3±1.6
Haoanwangmieduan	61.0±6.7	2103.7±8.8	2914.7±5.6	Manyougu	75.7±4.3	802.3±1.7	1093.7±4.7
Haoannongmiemen	57.7±8.9	759.3±9.8	1131.3±7.5	Menglaixiangmi	76.0±5.0	1694.0±5.0	2944.7±2.7
Haodilahao	61.0±8.4	507.0±5.3	433.3±5.7	Qiguizao	64.3±1.6	1515.3±3.3	2316.7±1.3
Haoanwangmienai	66.0±8.9	1777.3±6.9	1915.0±7.4	Tianza 58	56.0±5.0	2324.7±1.7	3913.3±3.2
Aleixing	71.0±9.7	557.7±2.3	505.3±1.8	Jingnong	75.3±2.7	1488.3±2.3	1975.7±6.1

3.3. Detection and Analysis of Nutritional Quality

3.3.1. Protein Detection and Analysis

Rice protein content is an important nutritional quality trait. To evaluate whether the rice is of high quality, according to the farmers' words, it should be good planting, good-looking, delicious, rich in rice, and fragrant. Good food corresponds to the cooking and eating quality of rice. The main components of rice are starch and protein. Rice protein is a high-quality plant protein. The protein obtained from eating rice accounts for 41%-46% of the body's total protein intake, which is an important source of nutrition for the human body. The protein content of rice is an important factor affecting the nutritional quality of rice, and it plays a key role in its cooking and eating quality. Generally, varieties with high protein content tend to have hard rice and poor palatability. In this experiment, the highest protein content in polished rice was Baimazhagu, which was as high as 8.52 $mg.g^{-1}$, and the lowest was Haomuxi, which was as low as 5.29 $mg.g^{-1}$. Through comparative analysis of the level of protein content, it has made a very important basis for selecting high-quality varieties of rice.

Table 8. *Detection results of protein content in milled rice.*

Number	Protein content ($mg.g^{-1}$)	Number	Protein content ($mg.g^{-1}$)	Number	Protein content ($mg.g^{-1}$)	Number	Protein content ($mg.g^{-1}$)
Xixianmagu	8.35±0.10	Haogaogongcheng 1	7.33±0.02	Haobierao	7.46±0.01	Laomianxianggu	7.32±0.02
Maxiangu	6.68±0.01	Haogaogongcheng 2	7.38±0.01	Haojingea	7.44±0.01	Laozhaigu	6.81±0.02
Dahangu	6.81±0.03	Haohaonen	7.71±0.04	Haomenlia	6.98±0.02	Manyougu	6.79±0.01
Haosa	7.24±0.05	Kufaku (4)	7.90±0.05	Jiangdongdabaigu	6.94±0.05	Menglaixiangmi	6.53±0.02
Haobawan 1	6.88±0.02	Haomuxi 1	7.33±0.03	Baxidabaigu	7.15±0.03	Qiguizao	7.68±0.03
Haobawan 2	8.14±0.04	Haomuxi 2	6.98±0.03	Xiaobaigu	6.87±0.02	Taiguoruanmi	7.31±0.02
Haobawan 3	7.69±0.02	Haomuxi 3	5.29±0.06	Ruanbaigu	7.13±0.02	Tianza 58	7.00±0.03
Haobawan 4	7.30±0.05	Haomuxi	7.72±0.02	Babaogu	6.87±0.01	Jingnong	6.99±0.04
Haobawan 5	7.81±0.04	Haomulei	7.86±0.05	Babaoxiang	6.82±0.02	9311	7.36±0.03
Haozhou	6.89±0.03	Xigu	7.30±0.02	Xiaoxianggu	7.88±0.01	Laoshuya-2	7.79±0.02
Haobi 1	6.50±0.04	Haoanwang	6.42±0.01	Baimazhagu	8.52±0.02	Yunjing 37	7.74±0.06
Haobi 2	7.33±0.06	Haoandian	7.01±0.01	Baiyouzhi	7.44±0.02	Yunhui 290	6.96±0.01
Fanhaopi	7.46±0.02	Haoanlang	6.59±0.01	Bendiyouzhi	8.30±0.02	Diantun 502	7.75±0.03
Haobihuang	7.28±0.05	Haoannong	7.88±0.07	Huangbansuo	7.60±0.06	Chujing 27	7.51±0.10
Haonaihuang	5.76±0.08	Haoannongmiemen	7.54±0.03	Laomiangu	7.18±0.01	Hexi 41	7.78±0.03
Haopi	7.86±0.01						

3.3.2. Detection and Analysis of Amino Acid Content

The nutritional quality of rice is not only related to the level of protein content in rice, but also depends on the content of various amino acids and their mutual balance. The content of amino acids in different rice is different. The content of arginine, aspartic acid, glycine, histidine, isoleucine, and proline varies little in different rice, and the content of other amino acids varies greatly. Among them, the highest valine content is Haogaogongwei, which is 3.98 $mg·g^{-1}$, the lowest is Qiguizao, which is 0.02 $mg·g^{-1}$, the highest leucine content is Haogaogongwei, which is 8.19 $mg·g^{-1}$, the lowest is Yunhui 290, which is 0.01 $mg·g^{-1}$, the highest isoleucine content is Qiguizao, which is 2.11 $mg·g^{-1}$, and the lowest is Haogaogongwei, which is 1.53 $mg·g^{-1}$, the highest methionine content is Baimazhagu, 13.27 $mg·g^{-1}$, the lowest is Jiangdongdabaigu, 0.01 $mg·g^{-1}$, the highest threonine content is Qiguizao, 12.71 $mg·g^{-1}$, the lowest is Haogaogongwei, 1.23 $mg·g^{-1}$, Qiguizao, with the highest lysine content, is 6.05 $mg·g^{-1}$, and the lowest is Haogaogongwei was 3.84 $mg·g^{-1}$, Chugeng 27 had the highest phenylalanine content, which was 25.60 $mg·g^{-1}$, and the lowest was Haobeirao, which was 6.91 $mg·g^{-1}$.

Table 9. *Amino acid content test results.*

Varieties	Ala	Arg	Asp	Cys	Glu	Gly	His	Ile	Leu	Lys
Haobawan	19.84±0.01	6.71±0.00	9.00±0.01	0.45±0.01	18.56±0.04	7.04±0.00	3.19±0.00	1.85±0.00	4.48±0.12	5.09±0.00
Haozhou	21.42±0.01	6.96±0.01	9.31±0.00	0.29±0.03	8.50±0.20	7.00±0.00	3.16±0.00	1.96±0.00	10.58±0.26	5.49±0.00
Haobi	19.06±0.01	6.59±0.00	8.95±0.01	0.31±0.02	12.82±0.03	7.06±0.00	3.21±0.00	1.80±0.00	3.69±0.29	5.20±0.00
Fanhaopi	18.45±0.01	6.49±0.00	8.73±0.00	0.47±0.02	14.5±0.04	7.08±0.00	3.22±0.00	1.76±0.00	0.74±0.09	4.73±0.00
Haobihuang	21.35±0.01	6.95±0.01	9.29±0.00	0.07±0.02	21.18±0.15	7.00±0.00	3.16±0.00	1.96±0.00	11.38±0.26	5.47±0.01
Baonaihuang	20.79±0.01	6.87±0.01	9.18±0.01	0.46±0.01	4.81±0.18	7.01±0.01	3.17±0.00	1.92±0.00	5.39±0.04	5.33±0.00
Haogaogongcheng	18.44±0.01	6.49±0.00	8.72±0.01	0.55±0.01	12.29±0.03	7.08±0.00	3.22±0.00	1.76±0.00	0.58±0.18	4.723±0.00
Haogaogongwei	15.03±0.00	5.94±0.00	8.06±0.00	0.88±0.01	8.36±0.20	7.16±0.00	3.29±0.00	1.53±0.00	8.19±0.03	3.84±0.00
Haohaonen	18.6±0.01	6.51±0.01	8.75±0.01	0.60±0.01	8.65±0.02	7.07±0.00	3.22±0.00	1.77±0.00	1.10±0.12	4.763±0.01
Kufagu 4	16.52±0.10	6.18±0.00	8.35±0.00	0.70±0.01	9.43±0.01	7.13±0.00	3.26±0.00	1.63±0.00	4.26±0.10	4.73±0.01
Haomuxi	20.35±0.10	6.80±0.00	9.10±0.00	0.07±0.01	13.28±0.10	7.03±0.00	3.19±0.00	1.89±0.00	4.37±0.06	5.30±0.00
Haomulei	15.72±0.00	6.05±0.00	8.19±0.00	0.82±0.00	7.68±0.04	7.15±0.00	3.28±0.00	1.57±0.00	5.83±0.01	4.02±0.00
Xigu	19.92±0.01	6.73±0.00	9.02±0.01	0.57±0.00	9.32±0.04	7.04±0.00	3.19±0.00	1.86±0.00	4.85±0.07	5.11±0.00
Haoanwang	22.49±0.01	7.14±0.00	9.52±0.01	0.09±0.01	14.61±0.04	6.97±0.00	3.14±0.00	2.03±0.00	14.51±0.13	5.77±0.00
Haoandian	19.93±0.02	6.60±0.00	8.86±0.00	0.33±0.01	10.57±0.28	7.06±0.00	3.21±0.00	1.81±0.01	5.12±0.26	4.90±0.00

Varieties	Ala	Arg	Asp	Cys	Glu	Gly	His	Ile	Leu	Lys
Haoanlang	16.25±0.01	6.14±0.00	8.30±0.00	0.67±0.00	16.08±0.20	7.13±0.00	3.27±0.00	1.61±0.00	3.98±0.01	4.16±0.01
Haoannong	19.64±0.01	6.68±0.00	8.96±0.00	0.24±0.01	7.20±0.20	7.04±0.00	3.20±0.00	1.84±0.00	5.31±0.03	5.03±0.01
Haoannongmiemen	20.74±0.01	6.86±0.00	9.17±0.01	0.15±0.02	12.11±0.35	7.02±0.00	3.17±0.00	1.91±0.01	8.40±0.10	5.32±0.00
Haobierao	15.88±0.00	6.08±0.00	8.22±0.00	0.73±0.01	7.69±0.06	7.14±0.00	3.27±0.00	1.58±0.00	7.80±0.04	4.06±0.00
Haojinga	18.96±0.02	6.57±0.01	8.82±0.01	0.37±0.01	7.05±0.04	7.06±0.01	3.21±0.00	1.79±0.00	4.07±0.08	4.86±0.01
Haomenlia	21.81±0.01	7.03±0.00	9.38±0.00	0.10±0.03	12.42±0.38	6.99±0.00	3.15±0.00	1.99±0.00	12.39±0.23	5.60±0.01
Jiangdongdabaigu	17.29±0.02	6.31±0.01	8.50±0.00	0.62±0.01	4.75±0.03	7.11±0.00	3.24±0.00	1.68±0.00	4.22±0.07	4.43±0.01
Baxidabaigu	22.02±0.00	7.06±0.00	9.42±0.00	0.21±0.02	20.05±0.02	6.98±0.00	3.15±0.00	2.00±0.00	14.35±0.15	5.65±0.00
Xiaobaigu	17.47±0.00	6.33±0.00	8.54±0.00	0.37±0.01	7.54±0.09	7.10±0.00	3.24±0.00	1.69±0.00	0.41±0.10	4.47±0.00
Ruanbaigu	21.07±0.01	6.91±0.00	9.24±0.00	0.05±0.02	31.92±0.43	7.01±0.00	3.17±0.00	1.94±0.00	11.79±0.13	5.40±0.00
Babaogu	18.52±0.05	6.49±0.01	8.73±0.01	0.30±0.02	15.33±0.40	7.08±0.01	3.22±0.00	1.76±0.00	1.74±0.25	4.73±0.02
Babaoxiang	18.52±0.02	6.50±0.01	8.74±0.00	0.46±0.02	15.8±0.04	7.08±0.00	3.22±0.00	1.76±0.00	5.81±0.17	4.74±0.01
Xiaoxianggu	17.47±0.01	6.33±0.00	8.54±0.01	0.42±0.01	30.68±0.59	7.10±0.00	3.24±0.00	1.69±0.00	1.31±0.05	4.47±0.00
Baimazhagu	22.18±0.01	7.09±0.01	9.46±0.00	0.22±0.01	34.44±0.20	6.98±0.00	3.14±0.00	2.01±0.00	13.25±0.07	5.69±0.00
Baiyouzhi	21.51±0.00	6.98±0.00	9.32±0.01	0.35±0.00	9.61±0.32	7.00±0.00	3.16±0.00	1.97±0.00	11.35±0.01	5.52±0.00
Bendiyouzhi	19.51±0.00	6.66±0.00	8.94±0.01	0.36±0.01	20.02±0.02	7.05±0.00	3.20±0.00	1.83±0.00	7.78±0.13	5.00±0.00
Huangbansuo	17.67±0.00	6.37±0.00	8.58±0.01	0.55±0.01	10.08±0.29	7.10±0.00	3.24±0.00	1.71±0.00	0.76±0.04	4.52±0.01
Laomiangu	21.3±0.01	6.95±0.00	9.28±0.00	0.05±0.02	2.75±0.09	7.00±0.00	3.16±0.00	1.95±0.00	11.84±0.15	5.46±0.00
Laomianxianggu	21.51±0.01	6.98±0.00	9.32±0.01	0.05±0.02	7.64±0.20	7.00±0.00	3.16±0.00	1.97±0.00	12.67±0.10	5.52±0.00
Laozhaigu	17.00±0.00	6.26±0.00	8.44±0.00	0.59±0.02	8.89±0.07	7.11±0.00	3.25±0.00	1.66±0.00	2.84±0.12	4.35±0.00
Manyougu	19.91±0.00	6.73±0.00	9.01±0.00	0.08±0.02	5.17±0.16	7.04±0.00	3.19±0.00	1.86±0.00	0.03±0.19	5.10±0.01
Menglaixiangmi	18.46±0.02	6.49±0.01	8.73±0.01	0.34±0.02	7.22±0.02	7.08±0.00	3.22±0.00	1.76±0.00	4.14±0.14	4.72±0.01
Qiguizao	23.58±0.01	7.31±0.00	9.73±0.00	0.57±0.03	50.4±0.40	6.94±0.00	3.12±0.10	2.11±0.00	4.25±0.26	6.05±0.00
Taiguoruanmi	20.96±0.01	6.89±0.00	9.22±0.00	0.06±0.03	3.61±0.23	7.01±0.00	3.17±0.00	1.93±0.00	9.48±0.29	5.37±0.10
Tianza 58	22.34±0.01	7.11±0.00	9.49±0.01	0.37±0.04	17.55±0.28	6.97±0.00	3.14±0.00	2.02±0.00	17.36±0.40	5.73±0.00
Jingnong	21.77±0.01	7.02±0.00	9.38±0.00	0.40±0.03	30.25±036	6.99±0.00	3.15±0.00	1.98±0.01	16.27±0.22	5.58±0.01
9311	16.48±0.00	6.18±0.00	8.34±0.00	0.58±0.01	13.63±0.07	7.13±0.00	3.26±0.00	1.62±0.01	3.79±0.03	4.22±0.00
Laoshuya-2	15.22±0.01	5.97±0.01	8.10±0.00	0.77±0.01	11.67±0.03	7.16±0.00	3.29±0.00	1.54±0.00	7.35±0.04	3.89±0.00
Yunjing 37	18.02±0.06	6.42±0.01	8.64±0.01	0.4±0.01	17.02±0.49	7.09±0.00	3.23±0.00	1.73±0.00	0.15±0.14	4.61±0.02
Yunhui 290	17.89±0.01	6.4±0.00	8.62±0.00	0.41±0.03	6.08±0.28	7.09±0.00	3.23±0.00	1.72±0.00	0.01±0.31	4.58±0.00
Diantun 502	17.89±0.02	6.97±0.01	9.32±0.01	0.15±0.02	11.02±0.15	7.00±0.00	3.16±0.00	1.96±0.00	11.09±0.28	5.51±0.01
Chujing 27	22.37±0.02	7.12±0.01	9.49±0.00	0.57±0.04	21.08±0.27	6.97±0.00	3.14±0.00	2.03±0.01	19.34±0.40	5.73±0.01
Hexi 41	18.62±0.01	6.52±0.00	8.76±0.00	0.29±0.02	15.37±0.17	7.07±0.00	3.22±0.00	1.77±0.00	4.36±0.12	4.77±0.00

Table 9. *Continue.*

Varieties	Met	Phe	Pro	Ser	Thr	Tyr	Val	EAA	TAA
Haobawan	6.18±1.27	16.47±4.10	6.09±0.20	3.55±2.17	5.79±0.22	5.93±2.24	1.91±0.56	15.10±5.93	99.22±6.70
Haozhou	6.6±2.90	22.24±3.42	6.04±0.91	0.76±0.02	7.08±1.62	5.60±1.41	4.59±2.87	10.53±6.30	85.30±8.93
Haobi	7.61±2.97	17.79±2.40	6.07±3.20	2.74±1.62	7.01±2.32	5.83±3.51	3.71±1.22	15.46±3.91	88.23±9.87
Fanhaopi	4.38±2.74	12.96±2.82	6.13±1.35	5.99±0.52	4.61±2.43	6.22±3.70	0.20±0.02	17.43±9.43	100.92±1.81
Haobihuang	9.51±5.47	20.27±5.90	6.04±2.10	0.87±0.02	8.33±3.17	5.61±2.72	5.52±2.67	7.31±4.11	83.62±7.60
Baonaihuang	5.32±2.60	17.81±6.30	6.06±2.82	1.86±0.73	5.89±3.63	5.73±2.31	2.21±3.94	15.21±7.30	96.52±8.21
Haogaogongcheng	3.79±2.07	13.49±4.14	6.13±2.26	6.02±2.51	4.43±1.81	6.22±1.30	0.16±0.03	18.84±3.75	99.49±5.74
Haogaogongwei	1.10±0.33	7.22±2.55	6.31±2.34	12.02±5.86	1.23±3.71	6.90±2.63	4.04±0.62	27.34±9.05	104.83±8.46
Haohaonen	2.10±0.27	12.41±3.25	6.13±2.36	5.72±2.62	3.12±1.14	6.21±2.93	0.82±0.23	21.06±9.47	99.60±3.74
Kufagu 4	1.20±0.57	12.00±3.57	6.10±2.94	6.02±2.84	3.60±2.41	6.23±2.64	1.03±0.25	23.49±6.47	100.10±5.90
Haomuxi	7.60±5.37	20.50±4.62	6.13±2.30	2.21±1.14	7.43±3.23	5.81±2.45	4.42±1.90	10.16±5.20	80.91±6.34
Haomulei	0.10±0.10	9.10±3.31	6.21±2.17	10.82±5.74	2.00±0.91	6.81±2.82	4.82±2.71	25.18±6.24	102.60±8.70
Xigu	5.12±2.81	17.93±8.47	6.09±1.93	3.39±2.01	5.41±1.03	5.91±3.71	1.86±0.48	15.59±3.91	102.58±8.39
Haoanwang	9.60±7.51	24.51±7.40	6.00±3.51	1.14±0.67	8.84±4.17	5.37±3.06	6.75±4.99	6.35±9.20	82.98±9.00
Haoandian	5.26±2.67	16.82±9.27	6.11±2.13	4.79±2.04	5.73±2.07	6.07±2.55	2.45±1.97	14.48±2.33	89.25±8.79
Haoanlang	2.06±1.54	9.70±6.49	6.21±5.03	9.89±7.88	2.95±0.93	6.68±3.19	1.83±0.50	22.59±4.29	102.47±6.98
Haoannong	4.86±2.81	16.69±8.00	6.09±5.44	3.89±1.77	5.77±4.73	5.97±2.19	2.39±0.94	14.17±6.35	86.72±9.98
Haoannongmiemen	6.74±5.61	19.04±9.40	6.06±3.62	1.96±0.27	6.91±4.39	5.74±3.14	3.86±1.94	11.24±3.74	85.93±7.84
Haobierao	2.08±0.79	6.91±3.27	6.22±3.22	10.53±3.99	1.54±0.39	6.75±5.79	3.67±1.88	27.62±9.24	98.14±3.49
Haojinga	2.17±0.34	8.87±2.77	6.11±2.43	5.09±3.19	3.17±1.29	6.11±3.27	1.87±0.47	25.26±5.28	86.81±7.49
Haomenlia	7.02±4.71	21.84±9.30	6.02±2.37	0.07±0.01	8.13±2.43	5.51±2.11	5.89±2.37	8.21±6.92	72.71±9.37
Jiangdongdabaigu	0.01±0.01	9.70±3.29	6.17±2.46	8.03±5.20	2.65±0.74	6.46±1.39	2.19±1.11	23.71±3.99	97.55±9.38
Baxidabaigu	10.58±5.43	22.43±8.42	6.02±3.73	0.30±0.02	9.17±4.30	5.47±2.16	6.89±2.47	4.30±4.01	78.08±9.20
Xiaobaigu	2.06±1.17	12.86±6.49	6.17±2.40	7.72±3.91	4.06±2.71	6.42±4.21	0.23±0.05	18.89±7.41	87.12±8.04
Ruanbaigu	11.54±4.97	20.31±2.79	6.05±3.21	1.39±0.42	8.68±3.94	5.67±2.19	5.76±2.44	5.83±3.22	89.45±9.30
Babaogu	4.56±2.33	13.19±4.82	6.13±2.03	5.94±3.05	4.99±1.20	6.21±3.49	0.86±0.27	16.59±7.39	93.08±9.29
Babaoxiang	2.64±1.44	7.59±2.10	6.13±3.27	5.86±2.93	2.79±0.42	6.20±2.19	2.59±0.69	27.14±9.81	90.58±2.40
Xiaoxianggu	6.86±3.74	9.79±6.84	6.17±2.19	5.86±3.28	4.84±2.37	6.42±2.95	0.30±0.05	17.65±7.42	108.62±6.44
Baimazhagu	13.27±6.99	22.90±6.35	6.01±3.29	0.58±0.37	9.09±4.10	5.44±3.74	6.14±2.13	5.26±3.11	101.50±9.41
Baiyouzhi	7.48±2.46	23.19±6.39	6.03±1.36	0.60±0.29	7.32±3.11	5.58±2.47	4.39±2.55	9.81±7.88	88.24±9.27

Varieties	Met	Phe	Pro	Ser	Thr	Tyr	Val	EAA	TAA
Bendiyouzhi	8.88±1.97	18.95±6.57	6.1±3.24	4.12±2.45	6.67±3.51	6.00±1.90	3.51±1.82	10.43±4.22	97.27±9.41
Huangbansuo	2.84±0.61	12.32±3.34	6.16±2.98	7.37±3.84	3.84±1.42	6.38±2.16	0.47±0.13	19.80±4.76	97.73±7.81
Laomiangu	6.13±4.27	22.37±4.91	6.04±3.52	0.97±0.04	7.47±3.67	5.62±2.17	5.41±3.65	9.09±2.36	74.01±8.47
Laomianxianggu	7.79±5.32	22.36±5.49	6.03±3.12	0.59±3.93	7.96±3.72	5.58±1.38	5.81±3.64	7.14±2.93	76.00±7.49
Laozhaigu	1.14±0.91	10.77±4.23	6.18±2.91	8.55±2.45	3.08±1.02	6.52±2.31	1.43±0.41	22.16±9.38	96.57±9.45
Manyougu	2.53±1.93	11.76±3.48	6.08±3.42	3.41±0.57	4.27±2.13	5.91±2.73	0.20±0.08	22.39±3.47	70.28±6.98
Menglaixiangmi	2.18±0.24	8.69±3.57	6.13±3.85	5.98±4.50	3.06±1.42	6.21±2.51	1.86±0.38	24.96±5.80	85.09±9.45
Qiguizao	3.11±6.73	25.81±6.29	5.97±3.93	3.05±1.92	12.71±4.21	5.15±2.18	0.02±0.04	4.11±2.45	79.82±8.49
Taiguoruanmi	3.82±2.01	19.81±3.76	6.05±3.19	1.56±0.41	6.82±2.49	5.69±2.71	4.42±2.36	11.6±5.20	68.23±8.47
Tianza 58	10.15±5.41	24.96±5.43	6.01±3.21	0.87±0.28	9.86±4.45	5.40±2.34	8.46±3.81	2.47±0.92	65.58±7.69
Jingnong	12.65±0.34	22.87±4.24	6.03±1.52	0.14±0.01	10.19±2.36	5.52±2.31	8.19±3.51	1.56±0.41	74.47±7.26
9311	1.81±0.68	9.49±7.35	6.20±4.62	9.47±5.17	3.02±1.21	6.63±2.37	1.75±0.23	22.25±8.20	99.56±3.13
Laoshuya-2	0.06±0.01	7.18±3.22	6.24±1.46	11.69±2.42	1.71±0.02	6.89±3.13	3.47±1.67	25.91±9.58	103.79±8.51
Yunjing 37	4.33±2.77	11.74±3.24	6.15±2.72	6.76±2.47	4.49±0.35	6.31±2.19	0.03±0.01	18.18±2.1	98.41±8.13
Yunhui 290	1.30±0.55	12.84±4.23	6.15±1.35	6.76±2.16	3.84±1.13	6.33±0.95	0.11±0.01	19.77±8.76	87.79±7.52
Diantun 502	4.88±2.41	20.73±6.43	6.03±2.31	0.66±0.22	7.56±3.63	5.59±2.75	5.32±1.69	10.02±7.32	66.61±3.91
Chujing 27	11.76±2.41	25.60±4.93	6.01±2.52	0.93±0.61	10.63±4.75	5.40±1.61	9.53±4.82	0.59±0.34	61.27±9.82
Hexi 41	5.35±2.34	15.84±3.21	6.13±2.72	5.69±1.34	5.50±1.92	6.18±0.51	2.04±1.37	14.42±8.27	89.58±6.30

3.4. Detection and Analysis of Grinding Processing Quality

The processing quality of rice mainly includes brown rice rate, polished rice rate and whole rice rate. Among the 39 japonica rice varieties introduced in Yunnan, the brown rice rate is quite different. Among them, Xiangzinuo No. 2 has the highest brown rice rate, reaching 79.22%, and except for Zinuo No. 6, the brown rice rate is the lowest (65.70%). Other varieties are brown rice. The rates remained between 67.41% and 79.22%. Among the 39 purple rice varieties tested, the highest rate of polished rice was Zigu 1 (97.28%), the lowest was Daheinuo (65.66%), the highest rate of polished rice was Zinuo 1 (99.00%)., Followed by Tianzimi No. 2 (98.48%), and the lowest is Heijienuo (46.98%). Interestingly, Zinuo No. 1 has the highest rate of whole rice, but the rate of brown rice is only 67.43%. Among the 39 purple rice varieties introduced in Yunnan, the brown rice rate is generally lower than the national first-level standard, and the whole rice rate reaches the first-level standard for high-quality rice.

Table 10. *Test results of grinding quality.*

Variety	Brown rice rate (%)	Polished rice rate (%)	Whole rice rate (%)	Variety	Brown rice rate (%)	Polished rice rate (%)	Whole rice rate (%)
Zinuodao	74.2±0.04	88.45±0.03	85.85±0.03	Zinuo 8	74.07±0.01	91.58±0.00	87.91±0.09
Jiegunuo 1	71.23±0.02	83.67±0.04	60.55±0.02	Zigu 3	71.57±0.03	90.38±0.03	87.33±0.05
Haokandou	72.68±0.05	72.91±0.02	82.76±0.05	Xiangzinuo 1	72.73±0.05	85.12±0.00	89.77±0.05
Shangyongzinuo	71.53±0.01	88.32±0.00	80.84±0.06	Xiangzinuo 2	79.22±0.03	89.85±0.05	97.00±0.05
Zinuo 1	67.43±0.03	87.56±0.05	99.00±0.05	Hanzinuo (007)	72.88±0.01	80.46±0.04	54.43±0.09
Zigu 1	79.03±0.04	97.28±0.01	98.18±0.08	Zimi 1	74.65±0.00	82.41±0.05	74.92±0.07
Heinuomi 1	72.63±0.01	88.84±0.06	84.29±0.05	Zigu 4	75.72±0.03	80.93±0.08	65.56±0.04
Haobixiang	67.93±0.06	81.65±0.04	88.98±0.01	Zinuo 9	72.77±0.04	90.83±0.07	97.74±0.00
Haobixiangnong	74.82±0.02	76.32±0.00	73.84±0.02	Heinuo	78.27±0.02	92.41±0.02	93.05±0.00
Zinuo 2	72.07±0.03	94.09±0.02	98.31±0.06	Zinuo 10	74.70±0.05	82.16±0.01	79.75±0.08
Zinuo 3	74.83±0.05	86.68±0.04	95.57±0.02	Zimi 2	69.70±0.03	89.40±0.06	98.48±0.04
Xiaoheinuo	73.96±0.02	65.86±0.04	79.96±0.07	Zigu 5	75.54±0.01	86.75±0.04	91.18±0.00
Zinuo 4	67.41±0.02	81.19±0.00	91.97±0.08	Heijienuo	74.87±0.00	85.41±0.00	46.98±0.06
Jiegunuo 2	73.13±0.03	92.76±0.05	80.80±0.08	Zimi 3	78.18±0.05	91.26±0.07	73.53±0.05
Zinuo 5	76.77±0.01	94.42±0.06	70.19±0.04	Daheinuo	75.45±0.07	65.66±0.05	89.71±0.03
Heinuomi 2	71.62±0.03	88.09±0.01	96.36±0.06	Heinuogu 1	75.35±0.04	90.36±0.08	89.14±0.08
Zinuo 6	65.70±0.04	94.88±0.05	86.63±0.01	Heinuogu 2	75.86±0.00	87.57±0.04	65.08±0.04
Zinuo 7	69.86±0.06	94.10±0.05	67.67±0.03	Jixuenuo	75.87±0.03	92.74±0.00	58.21±0.01
Zinuo (1)	72.40±0.02	93.83±0.04	94.50±0.05	Zinuo 11	69.65±0.02	78.07±0.06	74.48±0.00
Zigu 2	73.29±0.01	85.98±0.04	65.70±0.02				

4. Discussion

The physical and chemical indicators for evaluating rice quality at home and abroad are basically the same, generally including four aspects of rice appearance quality, nutritional quality, grinding and processing quality, and cooking and eating quality. The appearance quality mainly includes the grain type (grain length, grain width and aspect ratio). According to Wang et al., additive effects were dominant in the inheritance of grain length, grain width, ratio of length to width and grain thickness, but the ratio of length to width was significantly affected by additive and non additive effects [29]. The results also showed that grain shape traits such as grain length, grain width and ratio of length to width were mainly affected by gene additive effect [30]. Among the 39 purple

rice varieties tested, Zinuo 4 had the longest grain length (10.51 mm), and Heinuo had the longest grain length (10.51 mm). The grain length is the shortest (7.86mm), the grain width of purple glutinous rice is the narrowest (0.25 mm), and the width of Zinuo No. 3 is the widest (8.50 mm), the aspect ratio of purple glutinous rice is the largest (4.07), and the length and width of purple glutinous rice the ratio is the smallest, only 1.00 (Table 3). From the analysis of the test results of the appearance quality traits, it can be found that there are more slender types of purple rice tested, and there are rich variations in the grain type (grain length, grain width, and aspect ratio) (Table 3), which is the later fineness. The cultivation of new long-type high-quality purple rice varieties provides valuable genetic resource materials.

Traits such as amylose content, gelatinization temperature and taste value are important evaluation indicators for the cooking and eating quality of rice, and the viscosity of rice noodles is also an indicator of its cooking and eating quality. The gelatinization temperature directly affects the water absorption, expansion volume and elongation of rice during cooking. Gelatinization temperature refers to the irreversible expansion of rice starch granules when heated in water, that is, the temperature when birefringence disappears. Generally, the gelatinization temperature is indirectly reflected by the detection of rice alkali dissipation value. The higher the alkali dissipation value is, the lower the gelatinization temperature is [31]. Through the detection and analysis of 39 Yunnan purple rice germplasm resources, the results showed that among the 39 purple rice samples tested, the alkalinity dissipation value was the lowest level 1.7, the highest alkalinity dissipation value was level 7.0, and the low gelatinization temperature was the most. The second is the medium gelatinization temperature, the high gelatinization temperature is the least, the overall taste value of the tested rice is better (Table 5), the amylose content of 7 varieties of polished rice is less than 15% (Table 6). The results showed that all the 15 tested materials belonged to low amylose rice, and the amylose content was about 14%, the minimum was 13.48%, and the maximum was 15.43%; All of them reached the first grade high quality rice standard [32]. The amylose content of some rice varieties in our experiment is lower than 15%, which proves the superiority of some rice varieties and provides an important basis for further obtaining better quality rice. When the temperature is heated from 50°C to 95°C, when it is cooled to 50°C again, the viscosity of Tianza 58 increases most obviously. Although the viscosity of different varieties of rice shows an increasing trend during the heating process, the increasing speed is faster or slower. During the cooling process, the viscosity of most rice will increase, but on the contrary, there are still a few rice that will decrease in viscosity (Table 7). Therefore, there are many variations in the amylose, gelatinization temperature, taste value, and rice noodle viscosity of Yunnan purple rice germplasm resources, which provides an important basis for future research on the cooking and eating quality of rice.

The nutritional quality of rice is mainly related to the level of protein content and the level of amino acid content in rice. The protein and composition had a great influence on the cooking characteristics such as water absorption and gelatinization. The total protein content affects the maximum water absorption of rice flour, the total protein content is high, the water absorption is small, otherwise, the difference in protein composition may be related to the change process and result of water absorption among varieties with the same protein content. In protein composition, albumin and gliadin have great influence on the thermodynamic properties of rice [34]. In this experiment, the highest protein content in polished rice was Baimazhagu, which was as high as 8.52, and the lowest was Haomuxi, which was as low as 5.29 (Table 8). For amino acids, different rice has different amino acid content. By analyzing the correlation between the physical and chemical characteristics of rice and the texture characteristics of rice and establishing the regression equation between texture characteristics and sensory and physical and chemical factors, the results showed that in addition to the main components of rice starch, total protein and water, Free amino acid content is also a key physical and chemical factor affecting rice taste quality [33]. Arginine, aspartic acid, glycine, histidine, isoleucine, and proline vary little in different rice, and the rest of the amino acids the content varies greatly. Among them, the highest valine content is Haogaogongwei, which is 3.98, and the lowest is Qiguizao, which is -10.85, the highest leucine content is Haogaogongwei, which is 8.19, and the lowest is Qiguizao, which is -21.25, the highest isoleucine content is Qiguizao, which is 2.11, the lowest is Haogaogongwei, which is 1.53, the highest methionine content is Babaoxiang, which is 2.64, and the lowest is Qiguizao, is -17.95, the highest threonine content is Haogaogongwei, which is 6.93, the lowest is Qiguizao, which is 5.15, the highest lysine content is Qiguizao, which is 6.05, and the lowest is Haogaogongwei. Wei is 3.84, Chugeng 27 has the highest phenylalanine content, which is 25.60, and the lowest is Haobeirao, which is 6.91 (Table 9). The detection and analysis of the protein content and amino acid content of different rice provides an important basis for future research on the nutritional quality of rice.

The processing quality of rice mainly includes brown rice rate, polished rice rate and whole rice rate. In the evaluation of rice quality, the whole rice rate is an important indicator [34]. When planting rice, different sowing, harvesting and storage periods may also lead to differences in the whole rice rate of rice [35]. Among the 39 japonica rice varieties introduced in Yunnan, the brown rice rate is quite different. Among them, the brown rice rate of Fragrant Purple Glutinous Rice is the largest, reaching 79.22%, and the brown rice rate of the other varieties is the lowest (65.70%) except for Zinuo No. 6 Keep it between 67.41%~79.22%. Among the 39 purple rice varieties tested, the highest rate of polished rice was Xiangzinuo (97.28%), the lowest was Daheinuo (65.66%), the highest rate of polished rice was Zinuo No. 1 (99.00%). Followed by purple rice (98.48%), the lowest is Heijienuo (46.98%). Interestingly, Zinuo No. 1 has the highest rate of whole rice, but the rate of brown rice is only 67.43%. Among the 39

purple rice varieties introduced in Yunnan, the brown rice rate is generally lower than the national first-level standard, and the whole rice rate reaches the first-level standard for high-quality rice. Due to the geographical characteristics of my country, the north is high and the south is low [36]; the rice heading rate is negatively correlated with the grain length and chalky grain rate; environmental factors such as geographic location and climate benefits have a certain impact on the heading rate.

5. Summary

The grain quality of rice in Yunnan purple rice germplasm resources was tested and analyzed. It was found that there were obvious variations in the appearance quality, grinding quality, nutritional quality, cooking and eating quality of the tested purple rice. In particular, the grain shape in the appearance quality, the whole rice rate in the grinding and processing quality, the amino acid content in the nutritional quality, the viscosity of the rice noodles in the cooking and eating quality, the taste value, and the gelatinization temperature and other important quality traits in the rice material the range of variation is large. The results of this study provide important genetic and breeding resources for the cultivation of new high-quality rice varieties.

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