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Evaluation of the Quality of New Japonica Rice Resources in Three Provinces of Northeastern China

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Abstract: It is important to improve the overall quality of rice grown in northeastern China, which is famous for its high yield. Therefore, it is necessary to study the quality of japonica rice resources in the region. This study analyzed 71 rice samples from the Liaoning, Heilongjiang, and Jilin Provinces, focusing on grain shape, endosperm composition, and taste. Significant regional differences were observed in taste and edibility, with the samples from Heilongjiang and Jilin generally scoring higher taste value, which was significantly higher than the Liaoning variety. However, the Liaoning varieties were more stable in terms of the sensory evaluation of taste. Obvious differences in grain length were detected among the samples, with the varieties from Jilin and Heilongjiang Provinces predominantly having short and medium-to-long grains, respectively, and those from Liaoning Province having diverse grain shapes. However, there was no correlation between grain shape and taste. This indicated that the taste of rice is not affected solely by its external morphology but also by multiple interacting factors. There were significant differences in endosperm composition among the three provinces, but the amylose content of the tested varieties was generally less than 18%, and the protein content was about 6%. Additionally, the Jilin Province varieties had the lowest apparent amylose content and long chain of amylopectin (Fb3), the Heilongjiang Province varieties had the lowest protein content, and there were more medium chains of amylopectin. Notably, protein content was negatively correlated with taste but positively correlated with pasting properties. It can be seen that the premise of varieties in different provinces showing good taste characteristics is to ensure the content of amylose and protein is low, and adjust the proportion of amylopectin chain length.

Keywords: rice; grain shape; endosperm composition; taste; protein

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1. Introduction

Northeastern China is the largest japonica rice production base in the country, with a cultivation area of >50% of the total acreage for this variety [1]. The Liaoning, Heilongjiang, and Jilin Provinces are the primary rice producers in China and are particularly important for the nationwide stability and security of the japonica rice market. Despite China's status as a developing country, the demand for high-quality rice has been rapidly increasing, driven by the increasing income levels of residents and shifts in consumer preferences. Chen et al. [2] comprehensively investigated the rice consumption patterns based on data obtained from supermarkets in the Yangtze River Delta region from 2015 to 2018 and predicted the rice demand trends from 2025 to 2040. Their findings revealed a steady increase in the consumption of intermediate- and high-grade rice varieties in China, indicating a growing focus on taste quality among consumers. Globally, japonica rice varieties renowned for their exceptional taste, such as Japan's Koshihikari, have set the benchmark for excellence in taste. Koshihikari, bred in 1956, has held a significant share of the Japanese rice market, accounting for >30% of the planted areas since 1972. To maintain and enhance this taste standard, Japan has embarked on a market-oriented breeding program [3] and has even succeeded in cultivating varieties whose taste quality surpasses that of Koshihikari in 1956 [4,5], highlighting the importance of continuous efforts toward improving rice palatability. So, in recent years, the selection and breeding of rice varieties with excellent taste has become the primary objective of breeding endeavors [6]. Rice quality encompasses various aspects, including processing quality, appearance, nutritional quality, and eating quality, with the latter being the most closely linked to consumer preferences. Edible rice must have a pleasant flavor and appealing visual characteristics and must be easy to process.

With the advancements in breeding techniques, numerous studies have been conducted on the current status of japonica rice in northeastern China in terms of taste quality. Ma [7] evaluated 23 northern japonica rice varieties and discovered that those from Heilongjiang exhibited the best qualities in terms of taste and appearance, and the rice varieties from Liaoning Province were the lowest ranking in taste but boasted the best head rice rate, indicating great potential for further improvement [8]. Chen [9] cultivated 12 japonica rice varieties in Gongzhuling, Changchun, and Wuchang, and identified significant regional differences in rice quality indexes. Specifically, the varieties grown in Wuchang exhibited superior processing quality, while those grown in Gongzhuling had a superior eating quality owing to the more suitable light and temperature conditions in this region. This illustrates that the place of origin has an important effect on rice taste.

The most important eating quality of rice is the palatability perceived during chewing, the core of which is the physical characteristics of rice such as viscosity, elasticity, and hardness, which are closely related to the endosperm composition [10,11]. A large number of studies have confirmed that AAC and PC are the main factors affecting the viscoelastic and gelatinizing properties of rice [12–14]. Previous studies on rice eating quality in the three provinces of Northeast China found that the central and western regions of Jilin Province have demonstrated that, among the different factors influencing the eating quality of rice, protein content and AAC were both significantly correlated with taste [15]. Other investigations have also shown that eating quality was negatively associated with amylose content, water absorption, and swelling rate, but positively correlated with gel consistency, setback value, and fat content. However, the correlation with protein content was not significant [16].

The taste of rice can be evaluated by comprehensively assessing its appearance, aroma, flavor, softness, and hardness through artificial sensory means. Although this approach is widely used, it is highly subjective and lacks absolute standards. Given the long duration, intricate preprocessing procedures, and large sample sizes required for sensory evaluation methods, alternative techniques are being actively explored. Previous studies have demonstrated that enhancing the breakdown value and reducing the setback value can enhance the eating quality of rice. Additionally, rice varieties with 14–16% AAC typically have superior eating quality. Therefore, this parameter can be more effectively assessed by using Rapid Visco Analyzer (RVA) combined with AAC analysis [17]. Wei et al. [18] reported a significant correlation between eating quality and all RVA traits. Notably, the taste value exhibited a highly significant positive correlation with breakdown value and peak viscosity but a significant negative correlation with final viscosity and pasting temperature. Furthermore, lipidomics techniques have emerged as a powerful tool for identifying differences in lipid composition among indica rice varieties of different grades (high, medium, and low). This approach allowed the establishment of a novel orthogonal partial least squares-discriminant analysis model, which can potentially replace the traditional sensory evaluation methods used for indica rice [19]. Currently, a specifically designed taste meter that accurately measures the taste value of rice-based meals represents the most reliable, minimal loss, and standardized calculation method available. This instrument offers a precise and objective means of evaluating the eating quality of rice that overcomes the limitations of subjective sensory evaluation.

In summary, even though numerous studies have recently examined the taste of japonica rice varieties grown in northeastern China, there remains a scarcity of comparative studies exploring differences in rice varieties across provinces in this region. Additionally, some rice resources lack representative and distinctive characteristics. The present study attempted to address this knowledge gap by selecting 71 varieties of edible japonica rice included in the regional experiment of edible rice in the provinces of Liaoning, Jilin, and Heilongjiang as test materials. These varieties were comparatively evaluated in terms of their taste characteristics. Furthermore, the quality of rice was comprehensively evaluated by analyzing its composition from various perspectives. The objective of this study was to describe the quality traits and genetic diversity of edible rice in northeastern China, elucidating the differences in quality among varieties and influencing factors. This comprehensive evaluation also aims to provide a scientific basis for the future selection and breeding of high-quality rice varieties in the region.

2. Materials and Methods

2.1. Materials

In recent years, regional experiments primarily aimed at enhancing rice taste have been conducted in the northeastern provinces of Northeast China, resulting in the approval of several varieties with extremely high taste qualities. In 2020, the following japonica rice resources were selected for the present study: (1) experimental materials comprising early-maturing rice from Liaoning Province, specifically from the Kaiyuan and Panjin districts; (2) regional test materials sourced from the Jiamusi Rice Research Institute in Heilongjiang Province; and (3) recently approved excellent varieties of mid to late-maturing rice from Jilin Province. The names and sources of these materials are detailed in Table S1.

2.2. Design of the Field Experiment

After selection, all the rice varieties were conventionally cultivated and managed. Once the rice plants ripened, 10 samples of each variety were taken from the field in the middle row and mixed for threshing.

2.3. Measurement of Rice Characteristics

2.3.1. Grain Shape

A ScanMakeri800Plus color platform scanner (Shanghai MICROTEK, Shanghai, China) was used to determine grain length, width, length/width ratio, and chalkiness.

2.3.2. Taste Analysis

Taste was determined by a Satake rice Taste Analyzer (Hiroshima, Japan), which is a new equipment that uses near-infrared reflection for functional inspection of rice viscosity, hardness, taste, and so on. For analysis with this piece of equipment, 30 g polished rice was weighed into a stainless-steel tank, washed with running water, drained, and reconstituted with water to bring the ratio of rice to water to 1:1.35. The sample was then soaked for 30 min. The stainless-steel pot was placed into the electric rice cooker, covered, steamed for 25 min, and kept warm for 10 min. Seven grams of steamed rice were placed into a stainless-steel ring with 30 mm diameter and 9 mm height, then crushed into a rice cake to be measured. The rice cake was placed in the measuring tank, and the rice taste analyzer was inserted to measure appearance, hardness, viscosity, balance, and taste value of the steamed rice sample. Three rice cakes were measured for each sample, and each sample was measured one time at the front and at the back faces of each cake.

2.3.3. Sensory Evaluation of Taste

The methods employed in this study adhered to the GBT 15682-2008 Sensory Evaluation Method for Cooking and Edible Quality of Paddy and Rice [20].

The locally produced variety Akita Komachi, whose palatability value is established as 81 points, was used as the control. Based on the established empirical formula, a percentile conversion of the palatability value for each sample was performed using the following equation:

$$Rice\ score = \frac{100 - Control\ score}{3 \times Comprehhensive\ score\ + Control\ score} \quad (1)$$

2.3.4. Determination of Water Content

Measured by drying method at 135 °C: 5 g rice flour was placed in an aluminum box in an oven at 135 °C, dried to constant weight, and cooled passively in the dryer. Percentage of quality difference before and after heating was then calculated.

2.3.5. Gelatinization Characteristics

Rice pasting properties were determined using a rapid viscosity analyzer (RVA) (Model 4, Newport Scientific, Sydney, Australia) from samples of milled rice flour, following the method of Umemoto et al. [21], as follows: 3 g rice flour was weighed, which is equivalent to 12% water content, followed by addition of 25 mL distilled water, increasing temperature from 50 °C to 95 °C, and then reducing temperature to 50 °C. Rice flour was gelatinized fully, and results were analyzed by TCW3 software (Thermal Cycle for Windows, Newport Science Corp, New South Wales, Australia)

2.4. Data Analysis

The DPS 15.10 data processing system was used to conduct the analysis of variance, multiple comparison test, and path analysis. The GraphPad Prism 8.2.1 mapping software was used to visualize the results.

3. Results and Discussion

3.1. Target Taste Characteristics of Japonica Rice Growing in Northeastern China and Their Coordination with Other Quality Traits

The sensory evaluation method is the most intuitive method to evaluate the taste quality of rice, and it is the intuitive feeling of rice after people taste steamed rice, including smell, color, appearance structure, palatability, taste, etc. The comprehensive evaluation represents the important basis of rice palatability [22]. Since the quantitative indicators usually measured by chemical methods cannot explain the overall status of rice palatability quality well, and chemical detection cannot fully explain the interaction of various sensory elements [23,24], sensory evaluation plays an irreplaceable role in rice quality evaluation [25]. Based on the results of the sensory evaluation of taste conducted in this study (Table 1), it is evident that the average comprehensive score of rice varieties from Liaoning Kaiyuan was superior to that of those from Jilin, Heilongjiang, and Liaoning Panjin, in this order. Notably, the coefficient of variation was highest for Liaoning Panjin and lowest for Liaoning Kaiyuan, with the other two provinces exhibiting similar patterns. In terms of smell, the highest average value was obtained for the varieties from Heilongjiang, followed by those from Liaoning Panjin, Jilin, and Liaoning Kaiyuan. In terms of appearance, the rice varieties were ranked as follows in descending order: Liaoning Kaiyuan > Jilin > Liaoning Panjin > Heilongjiang. In terms of palatability, Liaoning Kaiyuan was ranked first, followed by Heilongjiang, Liaoning Panjin, and Jilin. Finally, in terms of taste, Heilongjiang achieved the highest scores, followed by Liaoning Kaiyuan, Jilin, and Liaoning Panjin. Overall, the Kaiyuan varieties from Liaoning had the best sensory characteristics and highest trait stability, followed by those from Heilongjiang, but the variation in taste between the varieties was large.

Table 1. Differences in the taste characteristics of rice materials from northeastern China determined via sensory evaluation.

Region	Parameter	Score	Smell	Appearance	Palatability	Taste
Liaoning Kaiyuan	Value	0.90 ± 0.41 a	0.77 ± 0.35 a	0.97 ± 0.50 a	0.94 ± 0.45 a	0.75 ± 0.38 a
	Variable coefficient	0.45	0.45	0.52	0.48	0.50
	Range of variation	−0.05 to 1.33	−0.06 to 1.17	0.00–1.50	−0.13 to 1.60	−0.08 to 1.17
Liaoning Panjin	Value	0.67 ± 0.59 a	0.92 ± 0.46 a	0.78 ± 0.60 a	0.80 ± 0.53 a	0.53 ± 0.53 a
	Variable coefficient	0.87	0.50	0.77	0.67	0.99
	Range of variation	−0.31 to 1.38	−0.45 to 1.46	−0.18 to 1.40	−0.31 to 1.50	−0.27 to 1.25
Heilongjiang	Value	0.73 ± 0.49 a	0.94 ± 0.32 a	0.76 ± 0.66 a	0.83 ± 0.47 a	0.77 ± 0.35 a
	Variable coefficient	0.67	0.34	0.87	0.57	0.46
	Range of variation	−0.31 to 1.55	0.00–1.46	−0.33 to 1.82	−0.25 to 1.55	−0.08 to 1.20
Jilin	Value	0.90 ± 0.56 a	0.84 ± 0.66 a	0.84 ± 0.58 a	0.62 ± 0.68 a	0.59 ± 0.54 a
	Variable coefficient	0.62	0.78	0.69	1.10	0.92
	Range of variation	0.00–1.65	−0.29 to 1.94	−0.36 to 1.65	−0.31 to 1.73	−0.08 to 1.36

Note: a, b, c, and d represent significant differences at 0.05.

In addition, the varieties with high taste scores were mainly from Jilin and Heilongjiang, and the taste values of the Kaiyuan varieties from Liaoning were concentrated and mainly medium-to-upper scores (Figure 1). Compared with the locally grown Akita Komachi, a cultivar renowned for its exceptional taste, the scores of the studied cultivars were higher in terms of sensory evaluation of taste. As illustrated in Figure S1, the proportion of rice cultivars rated excellent in terms of taste was highest in the Jilin region, accounting for 35% of the total, followed by cultivars from Kaiyuan and Panjin in Liaoning Province. In contrast, the proportion of excellent rice cultivars in Heilongjiang Province was the lowest.

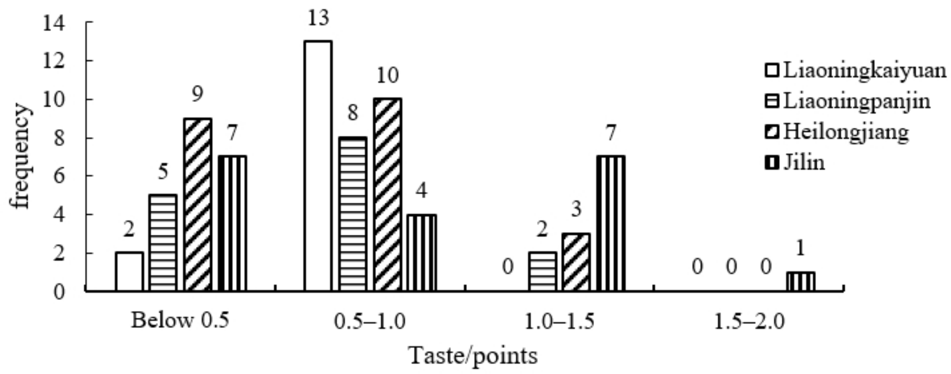

Figure 1. Distribution of times of japonica rice tasting value in different regions of northeastern China.

As shown in Figure 2 and Table S2, rice varieties of the finest quality were meticulously selected through comprehensive measurements of taste across all test samples. Significant differences were observed in taste, appearance, color, aroma, and palatability among the top-rated cultivars from different regions. Notably, the Jijing 830 cultivar from Jilin Province exhibited the highest overall score for taste and was rated to have exceptional smell and satisfactory palatability. The Xinhe 981 cultivar from Heilongjiang Province scored higher in appearance and taste while also possessing a pleasant smell and an excellent overall taste. The Hetianxiang No. 1 cultivar from Panjin, Liaoning Province, stood out for its exceptional palatability, whereas Yujingxiang No. 6 from Kaiyuan had a particularly delightful taste. Notably, this study revealed the existence of rice varieties in the provinces of northeastern China whose quality surpassed that of the renowned Akita Komachi cultivar. These findings suggest that China has the potential to cultivate rice varieties with even more exceptional flavor profiles, which could serve as the focal point for future breeding efforts.

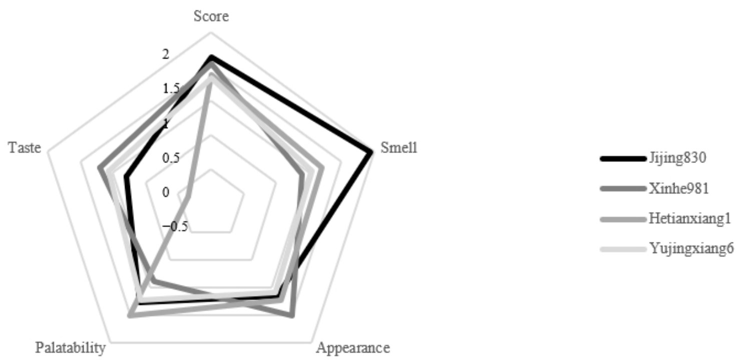

Figure 2. Comparison of the best-tasting varieties growing in different provinces of northeastern China in terms of taste characteristics.

The diverse quality characteristics of rice significantly affect its value across various segments of the rice commodity chain. Processing quality, for instance, holds the utmost importance for processors in determining the commodity's marketability. Similarly, appearance serves as the primary quality indicator for both consumers and sellers. Therefore, in addition to ensuring excellent taste, it is imperative to harmoniously enhance various quality traits, ultimately increasing the overall value of rice and satisfying consumer demands. In northeastern China, three primary types of rice have emerged with different grain lengths (after milling), i.e., short-grain rice (4–5 mm), medium-grain rice (5–6 mm), and long-grain rice (6–7 mm). As shown in Figure 3, Jilin Province exhibited a higher proportion of short-grained rice, whereas Heilongjiang Province is characterized by medium-grained varieties. Therefore, the selection of diverse grain shapes is a viable strategy for cultivating rice varieties with excellent taste qualities. Our analysis identified no discernible correlation between grain length and taste, indicating that the distribution of grain lengths across different regions is primarily driven by market supply and demand. This suggested that varieties with excellent eating qualities can be selected regardless of grain length. Furthermore, no significant negative correlation was detected between rice taste and chalkiness rate or processing quality, suggesting that these attributes can be developed in tandem.

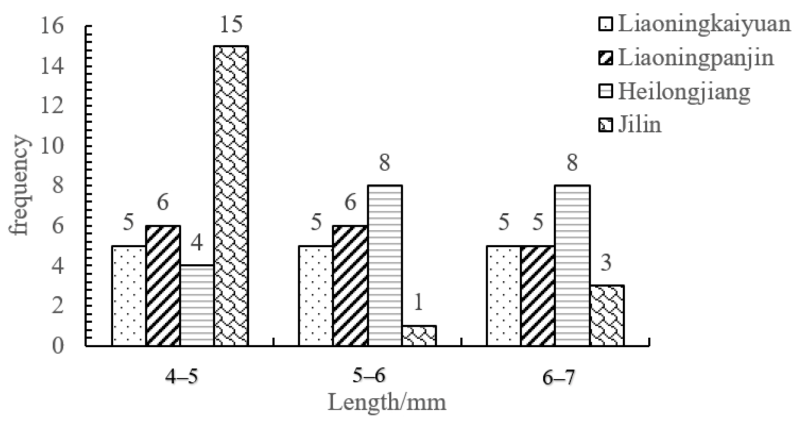

Figure 3. Distribution of rice varieties with different grain lengths in different regions of northeastern China.

In conclusion, it is feasible to select and breed varieties with favorable quality traits by adopting breeding techniques that allow the harmonious development of all quality-related aspects. This approach offers a promising avenue for enhancing the overall quality of rice, increasing its market value, and satisfying consumer preferences.

3.2. Differences in Taste among Rice Varieties Growing in Northeastern China

The concept of rice taste encompasses the sensory and emotional experience that humans derive from consuming rice. Consequently, sensory evaluation serves as the most direct and standardized approach to assess this parameter. This study adhered to the seven-point scoring system outlined in the GBT15682-2008 Grain and Oil Inspection protocol, which specifically focuses on the sensory evaluation of rice and its eating quality. Using scoring thresholds of ±3 (significant), ±2 (minor), ±1 (subtle), and the same, we comprehensively evaluated the appearance, aroma, taste, palatability, and overall score of the tested rice varieties in comparison with the control samples. This rigorous evaluation ensured accurate and consistent assessments, enabling us to draw meaningful conclusions about quality traits.

Given the intricacies involved in the sensory evaluation of taste, which encompasses various factors such as venue selection and reviewer biases (particularly when dealing with large sample sizes), conducting such tests can be challenging. Consequently, instrumental analysis has been increasingly used worldwide for indirectly assessing rice taste. The instruments used for this purpose include rice taste meters, RVA meters, texture meters, electronic noses, and electronic tongues, among others. In this study, rice taste was evaluated using a taste meter, and additional measurements of RVA characteristics and texture were also conducted. Significant differences in taste were observed among rice samples from different regions, with the varieties from Heilongjiang scoring higher than those from Jilin and Liaoning (Table 2). Further analysis of the best-tasting varieties revealed that those from Heilongjiang excelled primarily in appearance and aroma, while those from Jilin excelled in aroma and palatability, and the Liaoning varieties were superior in palatability and flavor. Therefore, it is imperative to further analyze the starch structure and endosperm composition of these cultivars to explain the observed regional differences in taste and identify potential areas for improvement.

Table 2. Differences in taste analyzer characteristics in different provinces of northeastern China.

Region	Parameter	Taste Value	Appearance	Flavor
Liaoning Kaiyuan	Value	75.63 ± 3.79 b	7.20 ± 0.42 b	7.34 ± 0.41 c
	Variable coefficient	0.05	0.06	0.06
	Range of variation	68.83–80.17	6.38–7.75	6.58–7.82
Liaoning Panjin	Value	77.31 ± 3.58 ab	7.50 ± 0.35 a	7.60 ± 0.42 bc
	Variable coefficient	0.05	0.05	0.05
	Range of variation	71.67–84.00	6.93–8.03	6.97–8.38
Heilongjiang	Value	78.36 ± 3.39 a	7.77 ± 0.47 a	7.89 ± 0.45 a
	Variable coefficient	0.04	0.06	0.06
	Range of variation	71.33–85.00	6.92–8.60	7.07–8.67
Jilin	Value	78.28 ± 2.93 a	7.67 ± 0.36 a	7.74 ± 0.35 ab
	Variable coefficient	0.04	0.05	0.04
	Range of variation	72.50–83.67	7.03–8.20	7.08–8.35

Note: a, b, and c represent significant differences at the 0.05 level.

In the analysis of structural characteristics, the rice varieties from Heilongjiang and Jilin, which exhibited superior viscosity and balance, were found to have a higher content of amylopectin medium chains (Fb1+2). This may be related to the variety types under investigation, suggesting that northern japonica rice cultivars with a higher proportion of medium chains exhibit a higher texture viscosity. Significant correlations were detected among RVA characteristics, taste scores, and sensory scores, aligning with the findings of previous studies [26–29]. This underscores the potential of instrumental analysis in providing valuable insights into rice taste and quality. However, no significant correlations were observed among texture characteristics, comprehensive score, and palatability, contrary to the findings reported by Okadome et al. [30]. This inconsistency remains a subject for future investigation. Nevertheless, given the strong correlation between the results of instrumental analysis and those obtained from sensory evaluation, we believe that the former is a necessary tool to evaluate rice taste in the case of large sample sizes. Such analysis can serve as a preliminary screening method, but it must be acknowledged that the most comprehensive and authoritative method for taste assessment remains sensory evaluation.

3.3. Some Reflections on the Breeding of New Varieties of Edible Rice

Rice taste is primarily determined by endosperm components, and the most important factor is amylose content [31]. Generally, the AC of rice with better taste is less than 18%. However, in contrast with previous research [32], a minimal correlation between amylose content and rice taste was observed in this study. Conversely, it was here found that the comprehensive score, palatability, taste, and aroma of the tested rice varieties exhibited a significant or extremely significant negative correlation with protein content, aligning with the findings of numerous other studies [33,34]. This may be due to the low amylose content of japonica rice varieties in Northeast China, and protein content plays a key role in the performance of taste value when amylose content is similar. And our previous study also found that for varieties with good taste, the influence of protein content on taste was higher than that of amylose content [35]. In general, the taste of japonica rice in Northeast China was generally better than that of indica rice in South China. Therefore, in this study, there was a more obvious correlation between protein content and food taste and other indicators. While the relationship between rice endosperm traits and taste remains a subject of ongoing investigation, extensive prior research suggests that it is imperative to concurrently reduce both amylose and protein content to enhance rice taste. When amylose content remains constant, differences in rice taste are often attributed to variations in amylopectin composition.

In this study, significant or highly significant differences were observed in the endosperm traits of rice cultivars across different regions of northwestern China (Table 3). Notably, the good-tasting varieties from Jilin and Heilongjiang exhibited lower Fb3 and protein content. These cultivars also demonstrated higher levels of Fb1+2. In contrast, the Jilin varieties exhibited the lowest AAC, with significantly higher Fb1+2 levels compared to other cultivars. Conversely, the Liaoning varieties, whose taste was poorer, had higher AAC and Fb3 values and lower Fb1+2 values. Notably, the differences in AAC and Fa between regions were relatively small, whereas the differences in Fb3 were more substantial. Overall, the variation in endosperm traits within each region was minimal, and values remained relatively stable. Furthermore, the majority of the best-tasting varieties had an amylose content of approximately 18%, a protein content ranging from 5.25% to 6.64%, a proportion of Fa between 33.36% and 33.42%, a proportion of Fb3 ranging from 12.12% to 13.82%, and a proportion of Fb1+Fb2 between 52.72% and 54.52%. Notably, Jijing 830 exhibited lower AAC and Fb3 values, while Hetianxiang 1 and Xinhe 981 had a lower protein content. These findings provide valuable insights into the relationship between endosperm traits and taste quality in rice, facilitating the selection and breeding of superior varieties for the food industry.

It was also observed that the varieties from Jilin and Heilongjiang with superior taste exhibited a higher ratio of short branches to long branches within their amylopectin structure. Notably, the Fb1+2 in these varieties was significantly higher than that in the Liaoning varieties, which are known for their inferior taste, contradicting previous findings. This suggested that an increase in the content of medium-length amylopectin chains in japonica rice may contribute to enhanced viscosity. Conversely, the Liaoning varieties exhibited a lower content of medium-length chains and a lower ratio of short chains to long chains (Fa/Fb3), coupled with a higher content of long chains, which likely accounted for their harder texture and inferior taste.

Currently, the regulation of genes associated with amylopectin structure is rather complex, and there have been limited direct applications in breeding. Therefore, to continuously improve rice taste quality, it is crucial to strengthen genetic association studies of basic materials and select those with a favorable genetic basis for taste as fundamental breeding parents. In particular, varieties with low amylose and protein contents should be selected.

Table 3. Differences in endosperm traits between rice varieties grown in different provinces of northeastern China.

Region	Parameter	AAC	Fa	Fb_3	Fb_1+Fb_2	Protein
Liaoning Kaiyuan	Value	16.88 ± 2.35 ab	33.38 ± 0.05 ab	12.69 ± 1.36 ab	53.93 ± 1.41 bc	6.23 ± 0.33 a
	Variable coefficient	0.140	0.001	0.107	0.026	0.053
	Range of variation	11.15–19.21	33.28–33.43	9.62–14.18	52.39–57.11	5.62–6.67
Liaoning Panjin	Value	17.64 ± 1.18 a	33.39 ± 0.040 a	13.08 ± 1.17 a	53.52 ± 1.21 c	6.51 ± 0.48 a
	Variable coefficient	0.070	0.001	0.089	0.023	0.073
	Range of variation	15.47–20.11	33.28–33.44	9.84–14.58	51.98–56.88	5.63–7.13
Heilongjiang	Value	17.75 ± 1.32 a	33.36 ± 0.037 bc	12.05 ± 1.10 bc	54.59 ± 1.14 ab	5.59 ± 0.33 b
	Variable coefficient	0.070	0.001	0.091	0.021	0.059
	Range of variation	14.48–19.70	33.29–33.42	10.02–13.88	52.69–56.69	4.91–6.25
Jilin	Value	16.19 ± 2.20 b	33.34 ± 0.053 c	11.47 ± 1.57 c	55.19 ± 1.62 a	6.23 ± 0.57 a
	Variable coefficient	0.140	0.002	0.136	0.029	0.092
	Range of variation	9.72–19.93	33.22–33.45	8.03–14.87	51.68–58.75	5.41–7.77
Best material	Yujingxiang6	18.94	33.42	13.82	52.76	6.64
	Hetianxiang1	18.31	33.42	13.86	52.72	6.10
	Xinhe981	18.31	33.37	12.30	54.33	5.25
	Jijing830	13.54	33.36	12.12	54.52	6.31

Note: a, b, and c represent significant differences at 0.05 levels.

4. Conclusions

The rice varieties from the three provinces of northeastern China tested in this study exhibited noticeable differences in terms of taste, and all ranked significantly higher than the Akita Komachi cultivar, a Japanese variety renowned for its excellent taste. In the sensory evaluation of taste, the Liaoning Kaiyuan varieties show the best average performance and stable taste traits. However, more varieties from Jilin and Heilongjiang achieved high scores, and evaluation using the rice taste analyzer also revealed higher values for these varieties. At the same time, the varieties from Jilin and Heilongjiang also showed high amounts of medium chains of amylopectin. The grain shape of rice varied greatly in different provinces, with the majority of the Jilin and Heilongjiang cultivars being short-grained and long-grained, respectively. The varieties from Liaoning exhibited diverse grain shapes, but some of them also had good taste. On the whole, the excellent-tasting varieties showed low amylose content and protein content. On this basis, the selection of excellent-tasting varieties in different regions could be further considered in combination with the proportion of amylopectin and grain shape.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/agronomy14081776/s1. Table S1. List of the rice cultivars used in this study. Table S2. Sensory evaluation of taste for the best-tasting rice varieties. Table S3. Analysis of the correlation between the results of the sensory evaluation of taste, assessment via taste analyzer, and RVA characteristics. Figure S1. Proportion of rice varieties with a good eating quality from different regions of northeastern China.

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