Scholar Publishing Group
Academic Journal of Agricultural Sciences
https://doi.org/10.38007/AJAS.2022.030406
ISSN 2789-8415 Vol. 3, Issue 4: 74-88

Entropy Weight Fuzzy Comprehensive Evaluation in Screening of Japonica Rice Quality

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Keywords: Entropy Weight, Fuzzy Comprehensive Evaluation Method, Rice Quality, Variety Japonica Rice

Abstract: More than half of the world's population is dominated by rice. In the context of reduced cultivated land and increasingly scarce water resources, increasing rice production has become an urgent problem in order to meet the needs of world's growing population. On the basis of previous work, this paper combines the entropy weight method with the fuzzy comprehensive evaluation method to expand the method of comprehensive evaluation of rice quality. The main purpose is to establish an entropy weight fuzzy comprehensive evaluation model and apply it to comprehensive evaluation of rice quality of japonica rice variety in 12 different producing areas. At the same time, identity the marker genotypes of parental yield traits, and found 31 marker genotypes are significantly correlated with the yield of parental yield traits. The two marker genotypes are related to the six traits of the parent; two marker genotypes are related to the 5 traits of parental at the same time; there are four marker genotypes associated with the four traits of the male parent; There are five marker genotypes associated with maternal features; there are three marker genotypes associated with the parental and maternal genetic traits; There are 15 marker genotypes associated with parental traits of individual traits. The marker genotype of the RM23~150/160 was positive for 4 genotype effects. The number of per panicle, daily yield per plant, ear length and number of secondary branches increased by 12.1%, 11.3%, 10.4% and 14.9%, respectively. The results showed that the whiteness, different cultivar rate, defect rate and amylose content may be the main indicators affecting differences in quality of various varieties' rice. Among the 12 varieties, the comprehensive quality of Ji japonica in 88 and Ji japonica in 83 was better, evaluation level is I; long white 19 and long white 25 have overall poor quality performance and the evaluation level is V.

1. Introduction

As one of the staple foods of our people, the quality of rice is closely related to people's living standards. As for the evaluation of rice quality, the current national standard (GB/T17891-1999) obviously requires 14 indicators [1], including brown rice rate, whole rice flour rate and chalkiness. It can be seen that rice quality evaluation needs to be comprehensively considered from multiple aspects to reflect its advantages and disadvantages comprehensively, objectively and truly [2].The basic idea of fuzzy comprehensive evaluation method is to apply the principle of fuzzy relation synthesis [3], and according to the existing or secondary attributes of the evaluated object, through the representation and description of its components, the comprehensive evaluation can obtain more objective results [4].From the ecological zone, there are hybrid rice in the north, japonica rice in the south and japonica rice in the middle [5].Hybrid japonica rice is very uneven among different regions. In recent years, hybrid japonica rice areas in the south (east and central China) have been popularized [6]. This area has been expanding year by year, mainly concentrated in the Taihu Lake basin [7], and new combinations have emerged. North japonica mainly distributed in Jilin and north China. In recent years, the area of japonica rice has increased. The design of index weight is a subjective weight method, because the subjective weight method changes with the professional level of experts. Therefore, to some extent, it limits the actual reflection of the actual situation of the research object [8].In order to solve the problem of reasonable weight design of each evaluation index [9], entropy weight method is adopted in this paper to improve rice quality index. The rice quality of each evaluation object was evaluated by fuzzy comprehensive evaluation method.

After more than 30 years of research, Chinese hybrid japonica rice has made some achievements, but it lags behind the development of japonica rice cultivation. The planting area of japonica rice accounts for about 70% of China's planting area [10], while hybrid japonica rice only accounts for about 3% [11]. Hybrid japonica rice still has great room for development [12]. The reasons for the slow development of hybrid japonica rice are many: the first situation is the continuous improvement of pure japonica rice varieties, the yield is not too much, the rice quality is better than japonica rice combination, so the promotion of hybrid japonica rice is facing a great challenge; Secondly, the lack of highly complex restorer lines in japonica hybrid rice breeding leads to the lack of competitive advantage in japonica hybrid rice combination, which is the fundamental reason. This is related to the breeding basis of early japonica hybrid rice. After the introduction of BoroII cytoplasm in China [13], a number of japonica sterile line were transferred, and no effective restorer lines were found in the rice varieties. The offspring were introduced into the restoration genes through reintegration with japonica rice and japonica restorer lines containing japonica rice lines were selected. The current rice restorer lines were selected from the descendants of japonica rice. Because the selection process mainly involved the selection of resilience in the breeding process, neglecting the selection of combining ability resulted in the low combining ability of non-glutinous rice restorer lines [14]. The selection of high GCA restorer line is a necessary condition for japonica hybrid rice combination, and it is also the only way to improve the competitive advantage of japonica hybrid rice.

At present, there are many researches at home and abroad. Taking Jilin province as an example, this paper collected data and conducted experiments in Jilin academy of agricultural sciences, and found that the population system based on entropy value was studied in the process of urbanization [15]. First of all, scholar Song found that 14 indicators were selected to construct the evaluation of population urbanization development level during the period of visiting statistical yearbook. Then, the entropy method is used to determine the weight of each index, and a multi-level fuzzy comprehensive evaluation model is established to evaluate the changes of urban and rural population system. The results show that the urbanization level of the province is currently in the process of transformation from grade 2 to grade 3 [16-17]. Wang described the cold tolerance

(CTBP) of 22 non-glutinous rice at different low temperature and different treatment days, and proposed the characterization method of CTBP [18]. The variation range and variation range of 22 japonica seedling death rates under 2℃/6 d low temperature treatment were the largest among different treatments at low temperature × treatment day (3×5), and the seedling death rates were reasonably distributed. CTBP evaluation of japonica rice at 2℃/6d was suggested. Long white No. 9, long white no. 19, Tong Yu No. 315, Keelung No. 603 and nine rice No. 58 belong to class 3 and have strong CTBP.CTBP from Jilin japonica rice was stronger in northeast China. Zhang J H in order to study the breeding and nitrogen levels on rice quality comprehensive influence, the Songhua River basin for 60 years to foster the 12 of japonica rice varieties were used in the three levels of in the meantime, the rice milling quality (brown rice percentage, the percentage of rice milling and the percentage of the ear), appearance quality (size and chalk percentage, chalky whiteness), eating and cooking quality, amylose content, gel consistency, peak viscosity, breakdown and setback) significantly improved, but the protein content decreased, the fall in the value of the crop nutrition [19]. Trace elements such as Cu, Mg and S content decreased, Fe, Mn, Zn, Na, Ca, K, P, B content increased. These changes in grain quality mean this. Using 19 conventional japonica rice varieties from Jilin academy of agricultural sciences as materials, Huang D used 24 pairs of SSR primers distributed on 12 chromosomes of rice to construct DNA fingerprint, and conducted cluster analysis on genetic similarity. With 24 pairs of SSR primers, 99 alleles were detected in 19 non-glutinous rice varieties, and 1-7 alleles were detected in each pair of primers, with an average of 4.1. Four selected core SSR primers (RM190, RM18, RM297 and RM5414) were used to distinguish 19 non-glutinous rice varieties and amplify 22 polymorphic fragments. Among them, RM190 and RM18 primers had the strongest ability to distinguish six japonica rice varieties [20]. Although the yield potential of rice increased, little is known about the effect of breeding on grain quality, especially at different nitrogen utilization levels.

In recent years, great progress has been made in using modern molecular breeding technology to innovate non-glutinous hybrid rice mother materials. For example, in the north, the herbicide tolerance Bar gene was transferred to a non-glutinous rice restorer line, and strains with high herbicide resistance and high recovery rate were selected. Transgenic restorer line C418 with resistance expression of Xa21 has been introduced into seed production. In this study, the concept of parental trait combination based on single-point marker genotypes "hybrid group" and "homozygous group" was slightly different from the traditional concept of general combination ability. This refers to the ability of two parents to bind, based on the genotype of the parental binding ability selected, and we call this the binding energy of the marker genotype.

On the basis of previous work, this paper combines entropy weight method with fuzzy comprehensive evaluation method to expand the comprehensive evaluation method of rice quality. The main purpose is to establish entropy weight fuzzy comprehensive evaluation model and apply it to the comprehensive evaluation of rice quality of 12 japonica rice varieties from different producing areas. The marker genotypes of parental yield traits were also identified and 31 marker genotypes were found to be significantly correlated with the yield of parental yield traits. Two marker genotypes were correlated with six parental traits. Two marker genotypes were correlated with 5 parental traits. There were 4 marker genotypes related to the paternal 4 personality traits. Five marker genotypes were correlated with maternal characteristics. There were three marker genotypes associated with parental and paternal genetic traits. There were 15 marker genotypes associated with parental traits of individual traits. The genotype effect of RM23~150/160 markers on 4 traits was positive. The number of grains per panicle, daily yield per plant, panicle length and secondary branch number increased by 11.5%, 11.3%, 10.2% and 14.9%, respectively.

2. Proposed Method

2.1. Evaluation Objects and Indicators

(1) Evaluation objects

A total of 12 japonica rice (Ji Japonica 88, Ji Japonica 83, Long white 9, Tonghe 836, Long white 19, Long white 25, white Japonica 1, Tong yu 315, jiudao58, jiudao63, Jilin agricultural university 858 and Jilin agricultural university 603) produced in 2015 and 2017 in Jilin province were selected as research and analysis objects in this paper.

(2) The evaluation index

Among the 14 indexes of japonica rice classification, brown rice rate, total rice milling rate, chalkiness, chalkiness rate, 8 indexes of gel concentration, amylose content, different variety rate and incomplete rate were used as the indexes for this analysis.

2.2. Fuzzy Entropy Weight Comprehensive Evaluation of Japonica Rice Quality

(1) Evaluation factors and evaluation sets,

Evaluation factor refers to specific indexes involved in rice quality evaluation, and the evaluation subset is a fuzzy subset composed of the measured values of these indexes, represented by F. In this paper, a total of 8 evaluation indexes were selected, and the evaluation subsets were expressed as F={brown rice rate, whole rice rate, whiteness, chalkiness, gel consistency, amylose content, different variety rate, incomplete rate}. The evaluation set is a set of different factor comment levels, represented by V. In this paper, the evaluation set is divided into 5 levels: excellent, good, in general, poor, namely, evaluation set V = {excellent, good, in general, poor} = { Ⅰ Ⅱ, Ⅲ, Ⅳ, Ⅴ}.

(2) PCR amplification

PXQ mating pattern (the same as NCII) was used to analyze the combination ability of parental traits, taking the cell average as the unit. The total rank method is a comprehensive evaluation of parents, namely the general combinatorial ability (GCA) effect and the specific combinatorial ability variance (VscA) of each parent's output and its constituent characteristics. Then, different grades are given according to the size of each value. The larger the value, the smaller the grade; the better the parents, the smaller the grade; VscA also ranks from large to small, with the higher the value, the lower the rank. Then calculate the sum of the GCA effect rating and VscA rating for each parent's 8 characters and rank them from smallest to largest. Finally, the sum of the levels of each parent GCA effect plus the level of VscA is used as the overall ranking order, and the smaller the grade, the higher the parental utilization rate. The evaluation of parental use value is based on the criteria described by Jilin institute of agricultural science and technology. On the basis of previous work, this study combined entropy weight method and fuzzy comprehensive evaluation method to expand the comprehensive evaluation method of rice quality. The entropy weight fuzzy comprehensive evaluation model was established and applied to the comprehensive evaluation of rice quality of 12 japonica rice varieties from different producing areas.

2.3. Research Methods

Depending on the nature or genus of the object being evaluated, it is also a feature and description of the component to which it belongs. Comprehensive evaluation can obtain more objective results. Subjective weighting method, therefore, will change as the personal knowledge of the experts, thus to some extent reflect the actual situation of the research object is to solve problems for the reasonable design of each evaluation index weight of entropy method combined with fuzzy comprehensive evaluation method is still an attempt in the field of rice quality comprehensive evaluation, so there is still an evaluation index. Some issues, such as the definition of thresholds for evaluation indicators, need further research and exploration.

(1) DNA extraction

In 2017, 12 restorer lines and 6 sterile lines were cut in leaf stage, and total DNA (containing nuclear DNA, chloroplast DNA and linear DNA) was extracted by SDS method. In this study, the concept of combining parental traits based on single-point marker genotype "hybrid group" and "homozygous group" calculation is slightly different from the traditional concept of general combinatorial ability. This refers to the ability of binding between two parents, which are determined according to the genotype of parental binding ability selected. In the process of improving the combining ability of parental traits, the comprehensive ability of marker genotypes should be avoided. The number of grains per ear and the number of effective panicles per plant are called the binding ability of marker genotypes. When homozygous trait mean and heterozygous trait mean f test showed significant differences in Jilin . It must also be noted that the closer the number of homozygous and heterozygous loci combinations, the better.

(2) Data analysis

PXQ mating pattern (the same as NCII) was used to analyze the combination ability of parental traits, taking the cell average as the unit. The total rank method is a comprehensive evaluation of parents, namely the general combinatorial ability (GCA) effect and the specific combinatorial ability variance (VscA) of each parent's output and its constituent characteristics. Then, different grades are given according to the size of each value. The larger the value, the smaller the grade; the better the parents, the smaller the grade; VscA also ranks from large to small, with the higher the value, the lower the rank. Then calculate the sum of the GCA effect rating and VscA rating for each parent's 8 characters and rank them from smallest to largest. Finally, the sum of the levels of each parent GCA effect plus the level of VscA is used as the overall ranking order, and the smaller the grade, the higher the parental utilization rate. Using 19 conventional japonica rice varieties from Jilin academy of agricultural sciences as materials, 24 pairs of SSR primers were distributed on 12 chromosomes of rice to construct DNA fingerprint. Cluster analysis of genetic similarity was carried out. Using 24 pairs of SSR primers, from 19 Ninety-nine alleles were detected in each non-glutinous rice variety, and the parental use value of 1-7 alleles per pair of primers was assessed based on the criteria described by Jilin institute of agricultural science and technology.

2.4. Calculation of Entropy Value and Entropy Weight

Entropy weight method: entropy weight method is an objective valuation method. In the process of specific use, entropy weight method calculates the entropy weight of each index by using information entropy according to the variation degree of each index, and then modifies the weight of each index by entropy weight, so as to obtain a relatively objective index weight.

Generally speaking, the smaller the entropy weight method used to determine the information entropy index weight of an index is, the greater the degree of variation of the index value, the more information it provides, and the greater the role it plays in the comprehensive evaluation, the greater its weight will be.

On the contrary, if the entropy weight method of determining the information entropy index weight of an index is larger, it indicates that the index is worth less variation, provides less information, plays a smaller role in the comprehensive evaluation, and has a smaller weight.

Scope of application: when business experience does not cause weight distortion, it is more applicable to entropy weight method. On the contrary, if weight distortion often occurs, the advantages of entropy weight method can only be brought into full play by combining expert scoring or evaluation. At the same time, before determining the weight, it is necessary to determine the direction of the index's influence on the target score, and preprocess or eliminate the nonlinear index.

The calculation formula of entropy is

$$\mathrm{H} = -\mathrm{k}\sum_{j=1}^{m} f_{ij} \ln f_{ij}, i = 1,2\ldots\ldots \mathrm{m}, j = 1,2\ldots\ldots \mathrm{n} \quad (1)$$

In the formula

$$f_{ij} = \frac{e_{ij}}{\sum_{j=1}^{m} e_{ij}}, k = \frac{1}{\ln n} \quad (2)$$

$$f_{ij} = \ln f_{ij} = 0 \quad (3)$$

After calculating the entropy value of each evaluation index, the entropy weight of each evaluation index can be calculated. We'll make $f_{ij} = 1$ cars only $\ln f_{ij} = 1$ That they may have, $\sum_{j=1}^{m} e_{ij}$ = 1, 2, 3, 4...Entropy weight of n, attribute weight

$$\mathrm{w}_{ij} = \frac{e_j}{\sum_{i=1}^{m=1} e_j} \quad (4)$$

When it is 0, its weight is 0. We can calculate the total contribution of scheme attribute X

$$\mathrm{E}_j = -k\sum_{j=1}^{m=1} p_{ij} \ln p_{ij} \quad , (5)$$

It's guaranteed to have a maximum of 1,

$$\mathrm{e}_j = 1 - E_j \quad (6)$$

For the consistency of contribution degree, some subjective weights can be borrowed λ_{j} It's going to fix it

$$\mathrm{W}_j = \frac{\lambda_j W_j}{\sum_{j=1}^{n} \lambda_j W_j} \quad (7)$$

The comprehensive weight of an index can be obtained by using its entropy weight

$$\beta_j = \frac{e_j W_j}{\sum_{j=1}^{m} W_j} \quad (8)$$

When all states are the same, the maximum value is taken.

$$e_{max} = \ln m \quad (9)$$

Entropy weight calculation formula

$$W_i = \frac{1 - H_i}{m - \sum_{j=1}^{m} H_i} (0 \le W_i \le 1), \sum_{j=1}^{m} W_i = 1 \quad (10)$$

3. Experiments

3.1. Experimental Setting and Data Collection

(1) Field investigation

In the first quarter of 2015, 6 sterile lines and 12 restorer lines were planted in the experimental station of Jilin academy of agricultural sciences. The seeds were planted on June 7 and transplanted to the large experimental field on July 10.72 hybrid combinations F1 were prepared at heading stage. In the same year, 16 F1 seed combinations with less than 100 seeds were added in Jilin agricultural base. In the spring of 2018, Fl and her parents planted in the experimental station of Jilin academy of agricultural sciences. On June 8, F1 seeds and parent seeds were immersed in 53% carbendazim powder for more than 1,000 times. After 24 hours, rinse with water. May 18 to transfer to the rice field for post planting. On June 13, it moved to Daejeon, with rows 17 to 20 centimeters apart. Complete random block arrangement, 3 repeats. Cultivation and management of the same field. After maturity, each sample map is used to study the effective number of ears per plant, and the number of ears with more than 5 sample fields is counted as the effective number of ears. Five main stems (the tallest ear) were randomly selected from each cell and brought back to the room to check the total number of grains in each panicle. Number of grains per panicle, length of panicle, number of main branches and secondary branches. Air dry weigh 1000 grains, 3 times repeat. When using the 31 marker genotypes screened in this study, attention should be paid to the number of traits related to the mating ability of the same marker genotype. Marker genotypes associated with only one trait of a trait can be modified directly according to the marker genotype. After each cell was harvested and desiccated, the cell yield was measured. The larger the index is, the highest value, the average value and the lowest value are the best value, the general value and the worst value respectively; Take the middle and average of the highest values as better values; Take the median value between the mean and the minimum value as the difference; The smaller the exponent, the better. The offspring were introduced into the restoration genes through reintegration with japonica rice and japonica restorer lines containing japonica rice lines were selected. The average yield of each plant is calculated by dividing the cell yield by the number of cells harvested in the figure. The average daily yield per plant is calculated by dividing the average yield per plant by the total growth period. The total growth period is the number of days from sowing to ripening.

(2) Determine evaluation criteria

After determining the evaluation factors and evaluation sets, it is necessary to clarify the critical points of the numerical interval of each evaluation index level for evaluation. Determine in the evaluation of focus to build five levels of assessment method of threshold value is as follows: the bigger the better (brown rice rate, rice milling rate, gel consistency) as small as possible index (chalk white degree, determined by the method provided by the white grain rate threshold value, the rate of change of different rate and imperfect, that is to say, the indicator, the greater the peak, mean and low respectively as the best value, average value and the worst; Take the middle and average of the highest values as better values; Take the median value between the mean and the minimum value as the difference; The smaller the index, the better. A number of japonica sterile lines were transferred, and no effective restorer lines were found in japonica varieties. The offspring were reintegrated with non-glutinous rice and the restorer lines of non-glutinous rice were selected. On the contrary, amylose content was the best index in the range. According to the requirements of GB/t17891-1999 for amylose content in non-glutinous rice and the relationship between amylose content and rice quality, as shown in table 1.

Table 1. Raw data of rice quality of each evaluation object

Segments	Brown Rice Rate (%)	The Whole Milled Rice Rate (%)	Whiteness (%)	White Grain Rate (%)	Gel Consistency (cm)	Amylose Content (%)	Variety Rate (%)	Imperfect Gain (%)
JiJing88	82.5	68.85	21.24	24.8	4.31	16.37	1.13	3
JiJing83	84.53	55.27	54.93	70.42	3.41	18.36	0.65	0.49
ChangBai93	82.42	51.38	44.85	66.87	6.03	11.9	0.38	0.42
TongHe836	84.38	54.79	23.27	38.08	3.54	13.19	0.88	1.74
ChangBai19	81.76	65.5	59.22	70.92	6.86	12.94	1	2.25
ChangBai25	82.15	68.22	14.38	19.34	6.35	16.64	0.5	0
BaiJing1	84.65	56.72	7.51	14.86	4.83	15.52	0.5	0.34
TongYu315	83.62	46.14	12.26	16.6	4.5	18.42	0.63	1.91
JIuDao58	82.98	58.69	8.66	13.04	5.45	14.38	0.51	0.25
JiuDao63	83.3	50.92	0.98	3.23	7.78	20.26	0.38	0
JiNongDa858	82.08	48.99	12.98	21.66	6.96	15.15	0.25	0.17
JiNongDa603	18.84	88.58	86.6	88.9	7.25	10.97	0.13	0.73

(3) Marker genotype

When using the 31 marker genotypes screened in this study, attention should be paid to the number of traits related to the mating ability of the same marker genotype. Marker genotypes associated with only one trait can be modified directly according to the marker genotype. Some marker genotypes are aligned with multiple traits, while others are reversed. For example, marker genotype RM1552~ 165/170 was positively correlated with effective panicle number per plant, daily yield per plant and combination ability of panicle length. With the help of RMl52~ 165/170, the parental combination ability of these three traits can be improved simultaneously. Similarly, RM23~ 150/160 could increase the combining ability of grain number per panicle, daily yield per plant, panicle length and secondary branch number at the same time. When using the 31 marker genotypes screened in this study, attention should be paid to the number of traits related to the mating ability of the same marker genotype. For marker genotypes related to traits of only one trait, the combination genotype RM208~ 185/175 can be modified directly according to the marker genotype, which has a negative effect on the binding ability of effective panicle per plant, and a positive comprehensive effect on the total number of grains per panicle, while the opposite direction is opposite. In the process of improving the combining ability of parental traits, the comprehensive ability of marker genotype with total grain number per ear and effective panicle number per plant should be avoided. However, marker genotypes that favor the combination ability of the two traits should be selected, and then the coordination parent of the two traits can be obtained through polymerization.

When using the other 31 marker genotypes screened in this study, attention should also be paid to the number of traits associated with the mating ability of the same marker genotype. Marker genotypes associated with only one trait can be modified directly according to the marker genotype. Some marker genotypes are aligned with multiple traits, while others are reversed. For example, marker genotype rm155-175/180 was positively correlated with the effective number of ears per plant, daily yield per plant and combination ability of ear length. With the help of RMl52~ 165/170, the parental combination ability of these three traits can be improved simultaneously. The higher the index is, the highest value, the average value and the lowest value are the best value, the general value and the worst value respectively. Take the middle and average of the highest values as better values; Take the median value between the mean and the minimum value as the difference; Similarly, RM23~ 150/160 could increase the combining ability of grain number per panicle, daily yield per plant, panicle length and secondary branch number at the same time. The combined genotype rm208-185/175 had negative effects on the binding ability of effective panicle per plant and positive effects on the grain number per panicle. In the process of improving the combining ability of parental traits, the comprehensive ability of marker genotype with total grain number per ear and effective panicle number per plant should be avoided. However, marker genotypes that favor the combination ability of the two traits should be selected, and then the coordination parent of the two traits can be obtained through polymerization.

4. Discussion

4.1. Evaluation Criteria and Critical Value Analysis

The critical points of each grade are determined as follows: excellent ($15 \leqslant x \leqslant 18$), good ($18 < x \leqslant 19$), medium ($19 < x \leqslant 20$), general ($x < 15$), poor ($x > 20$).The key points of each evaluation indicator are shown in table 2.

Table 2. Threshold value of each evaluation index

Evaluation Index	Excellent	Good	Middle	The General	Bad
Brown Rice Rate (%)	84.88	84.08	83.27	82.52	81.76
The Whole Milled Rice Rate (%)	68.85	62.94	57.03	51.59	46.14
Whiteness (%)	0.98	11.63	23.27	41.75	59.22
White Grain Rate (%)	3.2	17.01	30.81	50.86	70.9
Gel Consistency (cm)	7.78	6.69	5.6	4.5	3.41
Amylose Content (%)	16.00	18.00	19.00	15.00	20.00
Variety Rate (%)	0.125	0.35	0.58	0.86	1.13
Imperfect Gain (%)	0	0.47	0.94	1.6	2.25

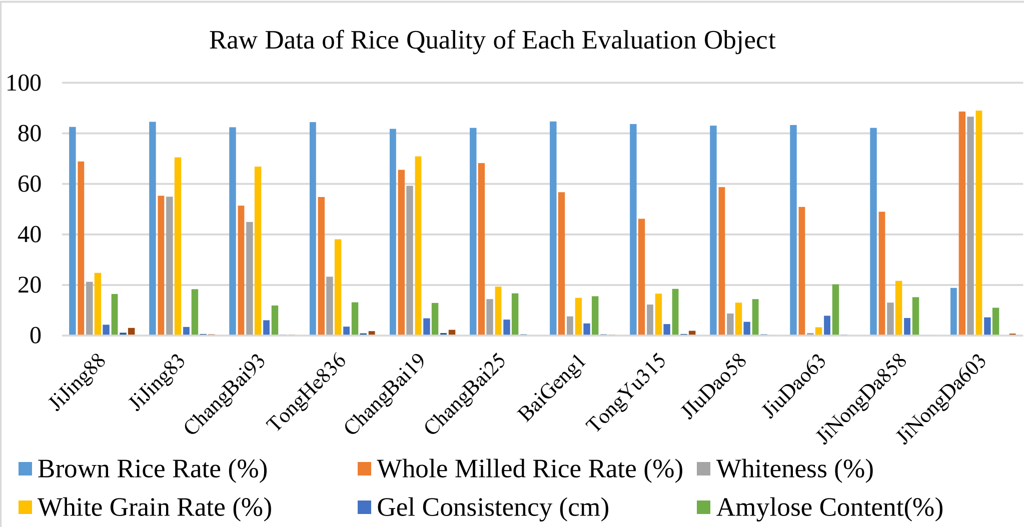

Figure 1. Raw data of rice quality of each evaluation object

Assessment set established five assessment levels of critical value as shown in figure 1, the method is as follows: the bigger the better (brown rice rate, rice milling rate, gel consistency) as small as possible index (chalk white degree, determined by the method provided by the white grain rate threshold value, the rate of change of different rate and imperfect, that is to say, the indicator, the greater the peak, mean and low respectively as the best value, average value and the worst; Take the middle and average of the highest values as better values; Take the median value between the mean and the minimum value as the difference; The smaller the better, on the contrary. The value of each index and the corresponding critical value can be seen that their mutual influence, interaction.

4.2. Calculate the Entropy Value and Entropy Weight of Each Evaluation Index

By standardizing the original data matrix, we first arrange the original data according to matrix x (m evaluation indexes and an evaluation objects) to form the original matrix. As shown in figure 2, since the dimensions of each evaluation index are different, all indexes must be standardized before comprehensive evaluation, so that they all fall into a uniform dimensionless interval. According to the method provided by the former method, specific standardization processing method is carried out to obtain the standardized matrix E= $(e_{ij})_{mxn}$ that type of (e_{ij}) Refers to the standard value of the JTH evaluation object on the evaluation index $(e_{ij}) \in [0, 1]$.

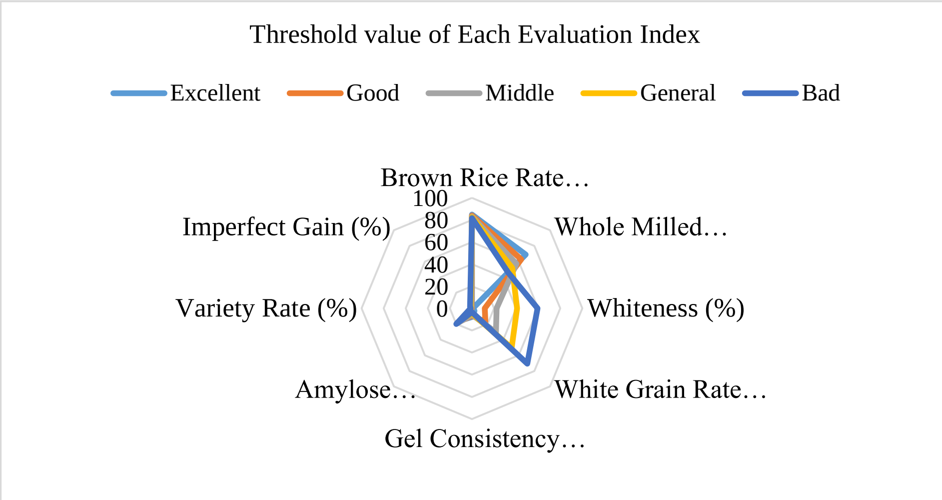

Figure 2. Threshold value of each evaluation index

By using the entropy weight calculation formula, the entropy value and entropy weight of the evaluation index can be analyzed, as shown in Figure 2.

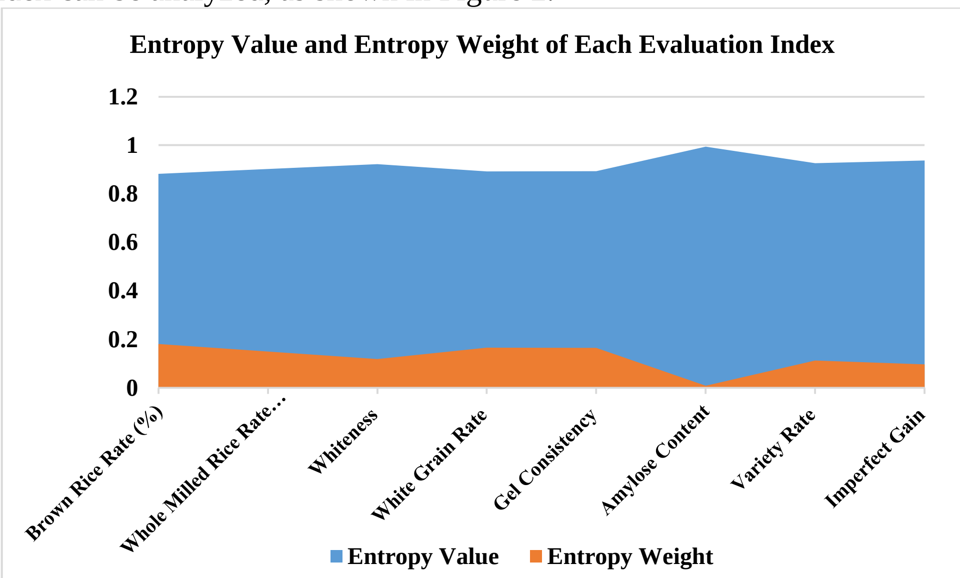

Figure 3. Entropy value and entropy of each evaluation index

In information theory, entropy reflects the degree of disorder of information. Among the 8 quality evaluation indexes involved, as shown in figure 3, the entropy values of brown rice rate, total rice milling rate, chalky grain rate and gel consistency are all small. The results show that the changes of these indexes are relatively orderly and there is little difference among the evaluation objects. Chalkiness degree, different variety rate, defect rate and entropy of amylose content are all large, indicating that the four indexes are relatively different among the evaluation objects. It may be the key index of japonica rice quality.

4.3. Construction of Fuzzy Relational Matrix

Single-factor evaluation is performed between the evaluation factor subset F and the evaluation set V of the evaluation object, and the single-factor fuzzy relation matrix R is established.

$$R = \begin{matrix} r_{11} & \cdots\cdots & r_{1k} \\ \cdot & & \cdot \\ & \cdot & \\ \cdot & & \cdot \\ r_{m1} & \cdots\cdots & r_{mk} \end{matrix} \quad (11)$$

Where m is the number of evaluation factors and k is the number of evaluation sets. R_{mk} Is the membership degree of evaluation index m to level k. The membership degree calculation functions of different types of indicators are different. The specific methods refer to Jilin agricultural science news. Through the comprehensive evaluation results of a series of experiments, we can know that the comprehensive evaluation method is

$$A = W^{o}R = \{W_1, W_2 \ldots\ldots W_n\} \begin{Bmatrix} r_{11} & \cdot & \cdot & \cdot & r_{1k} \\ \cdot & \cdot & & & \cdot \\ \cdot & & \cdot & & \cdot \\ \cdot & & & \cdot & \cdot \\ r_{m1} & \cdot & \cdot & \cdot & r_{mk} \end{Bmatrix} \quad (12)$$

In the formula, A is the comprehensive evaluation result, W is composed of the weight of each evaluation index, "o" is the fuzzy operating symbol in this paper, (fuzzy operator) is adopted, and R is the fuzzy relational matrix.

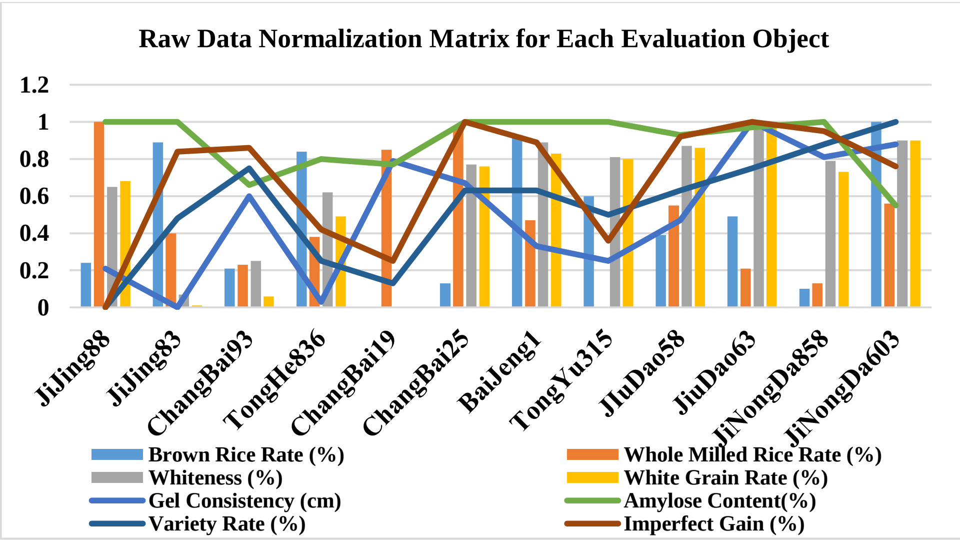

Figure 4. Raw data normalization matrix for each evaluation object

And evaluation index were compared as shown in figure 4 grade, auspicious japonica 58, 88, nine rice quality evaluation level for Ⅰ; The quality evaluation level of Long white 93, Long white

31, White Japonica 1 and Jilin agricultural university

858 was level 2.The quality evaluation rating for the Jilin 83 Ⅲ level; Tongyu no.315, tang no.236 and nine rice no.63 are rated as grade 4. Nine rice quality evaluation level for 58 and agricultural university 603 Ⅴ level.

5. Conclusion

Based on the above evaluation results, among the 8 evaluation indexes listed, there are relatively large differences in the subjects' whiteness, different variety rate, incomplete rate and amylose content. The results showed that the four indexes may be the key indexes of japonica rice quality difference. In addition, of the 12 non-glutinous rice varieties evaluated, 6 grade I and II varieties were produced from the northern rice producing areas. Five varieties belonging to grade 4 and 5 come from the northern rice producing areas of Songhua River and Tonghua City, which indicates that the quality of japonica rice in Songhua River area is superior to tonghua japonica rice. This may be related to the quality and climatic conditions of northern rice area and the abundant water resources which are usually better than Tonghua City.

In this experiment, the concept of parental traits and ecology calculated from single-point marker genotypes "experimental group" and "non-experimental group" was slightly different from the traditional concept of general combination state. This refers to the binding ability between two parents, which are determined according to the genotype of parental binding ability selected, which is called the marker genotype binding ability. While the mean value of homozygous group and the mean value of heterozygous group f in Jilin showed a very significant difference of $P<0.01$, it is noteworthy that the number of purebred and heterozygous locus combinations reached approximately the best.

Therefore, the comprehensive evaluation of japonica rice quality based on entropy weight fuzzy comprehensive evaluation method is not only simple, but also reliable. Rice quality is a comprehensive concept, mainly including appearance quality, processing quality, taste quality, nutritional quality, storage quality and sanitary quality. Entropy weight method combined with fuzzy comprehensive evaluation method is still an attempt in the field of rice quality comprehensive evaluation. Some problems, such as the definition of critical value of evaluation indicators, need further research and exploration.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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