International Journal of Applied Agricultural Sciences
2022; 8(6): 244-250
http://www.sciencepublishinggroup.com/j/ijaas
doi: 10.11648/j.ijaas.20220806.17
ISSN: 2469-7877 (Print); ISSN: 2469-7885 (Online)

Screening of New Wheat Varieties with Excellent Physical and Chemical Quality and Their Application in Food Processing

Aifeng Liu[1, *], Canguo Wang[1], Donggong Cheng[1], Jianjun Liu[1], Jianmin Song[1], Xinyou Cao[1], Cheng Liu[1], Jun Guo[1], Ran Han[1], Yan Zi[1], Faji Li[1], Shennan Zhai[1], Xiaolu Wang[1], Wenjing Xu[1], Kai Wang[1], Guang Qi[1], Wenwen Zhuang[2], Xin Sun[2], Guiling Chen[2], Zexin Xu[2], Zaidong Yang[2, *], Haosheng Li[1, *]

[1]Crop Research Institute, Shandong Academy of Agricultural Sciences, Key Laboratory of Wheat Biology and Genetics and Breeding in Northern Huang-huai River Plain, Ministry of Agriculture and Rural Affairs, National Engineering Research Center of Wheat and Maize, Shandong Technology Innovation Center of Wheat, Jinan Key Laboratory of Wheat Genetic Improvement, Jinan, China

[2]Shandong Luyan Agricultural Seed Co., Ltd., Jinan, China

Email address:

501365957@qq.com (Aifeng Liu)

[*]Corresponding author

To cite this article:

Aifeng Liu, Canguo Wang, Donggong Cheng, Jianjun Liu, Jianmin Song, Xinyou Cao, Cheng Liu, Jun Guo, Ran Han, Yan Zi, Faji Li, Shennan Zhai, Xiaolu Wang, Wenjing Xu, Kai Wang, Guang Qi, Wenwen Zhuang, Xin Sun, Guiling Chen, Zexin Xu, Zaidong Yang, Haosheng Li. Screening of New Wheat Varieties with Excellent Physical and Chemical Quality and Their Application in Food Processing. *International Journal of Applied Agricultural Sciences*. Vol. 8, No. 6, 2022, pp. 244-250. doi: 10.11648/j.ijaas.20220806.17

Received: November 3, 2022; **Accepted**: November 18, 2022; **Published**: November 29, 2022

Abstract: In order to fully understand the utilization value of the newly bred varieties (lines) in the application of food processing, which bred by the wheat breeding team of Shandong Academy of Agricultural Sciences in the past three years, the physical and chemical quality and food processing characteristics were measured and analyzed. And some new wheat varieties (strains) were selected out with combined or special use of steamed-bread, noodles or bread. Among them, variety Jimai 106 had excellent quality of bread, steamed-bread and noodles, LHSJ 156, Jimai 0435, Jimai 8365 had excellent quality of bread and noodles, and LHSJ 157 and Jimai 55 had excellent quality of bread and steamed-bread. And these varieties (lines) could be used as dual-purpose wheat. While varieties including Jimai 5022, Jimai 40, Jimai 5172, Jimai 108, Jimai 117 and Jimai 379 had excellent bread quality, Jimai 6174 had excellent steamed-bread quality, Jimai 6001, Jimai 899 and Jimai 4277 had excellent noodle quality, and all these varieties (lines) could be used as special wheat. All these provided theoretical support for the development and application of these new high-quality varieties. At the same time, the correlation between the bread neck length and the physical and chemical properties was discussed, as well as its effect on evaluating bread quality. It was believed that the increased neck length could be used as a quantitative index to evaluate bread quality, and could judge the bread quality preliminarily.

Keywords: Wheat (*Triticum aestivum*), Variety, Quality, End Use

1. Introduction

Wheat is one of the main food crops in China. Quality are one of the key screening indicators for wheat breeding, which not only affects the competition in the wheat market, but also affects food processing and flour manufacturers, and even is the purpose of wheat quality breeding [1]. The quality of wheat is closely related to the interests of food production enterprises, and the improvement of wheat quality has always been an important direction of domestic wheat breeding research [2-3]. Since the end of the last century and the beginning of this century, the quality improvement of special or dual-purpose wheat has been paid attention to [4-7], and new high-quality special or dual-purpose varieties have been

cultivated [8-12]. For improving the quality of wheat, Shandong Province has always been at the forefront of our country. It has taken the lead in cultivating variety Jinan 17, which is reputed to be "milestone" of high-quality wheat, and a number of high-quality wheats that have been widely promoted and utilized, such as Yannong 15, Jimai 19, Jimai 20, Yannong 19, Zhouyuan 9369, Yannong 999, Jimai 229, etc. In recent years, with the continuous development of society economy and the improvement of people's living standards, the consumption structure of residents focus has changed from on quantity to quality more. Therefore, increasing the quality of wheat and improving the performance of wheat products will greatly improve the quality of human life [13]. As a remarkable representative of high-quality wheat, Jimai 44 has been promoted and planted on a large scale in production, with a cumulative area of more than 333,300 hectares. On this basis, outstanding achievements have been made in wheat quality breeding, and a number of new high-quality wheat varieties (lines) have been bred, which belonging to different types in quality.

As we all known, the quality of varieties and their food processing characteristics determine the application prospects of their development and utilization. When a new variety (line) is released (screened), only by fully understanding its physical and chemical quality characteristics and food processing quality can it better exert its value in production and create greater economic and social benefits. In this research, the physical and chemical quality characteristics of the newly bred varieties (lines) are mainly analyzed to select high-quality varieties, and the food processing quality including bread, steamed-bread and noodle are evaluated to discuss the utilization value in the application of food processing. To provide theoretical data support for the development and application of these new high-quality varieties.

2. Materials and Methods

2.1. Description of Study Area

The new wheat varieties (Table A1) were planted in field at Jinan Breeding Test Base. Plots were used with an area of 6.0 m^2, and was repeated 3 times. After maturity, the variety grains of every plot were harvested separately, dried and stored separately too. The study site located at 36°65'00N latitude, 117°0'00 E longitude.

The flour was milled by Buhler mill according to AACC26-21A method. The grain protein content was determined by Foss Near-Infrared. The flour whiteness was measured by intelligent whiteness meter (WSB-IV). The gluten characteristics were determined by Glutomatic2200 gluten meter according to the national standard GB5506-85 method. According to AACC54-21 and AACC54-10 methods, dough rheological properties measured with FarinoGraph-E farinograph and Extensograph-E electronic extensometer of Brabender Company, Germany. The bread quality was evaluated according to the national standard GB/T 14611-2008 method. Use the slide caliper rule to measure the raw bread embryo height before entering the oven and the bread height, and the height difference is the increased length value of bread neck, its unit is mm. The quality evaluation of steamed-bread and noodles were conducted according to the national standard GB/T 17320-2013 method.

2.2. Statistical Analysis

The plots were conducted with data mean by EXCEL system, and the difference and correlation analysis were performed by Statistical Analysis System (SAS) version 9.4.

3. Results

3.1. Physicochemical Quality Characteristics of New Varieties

3.1.1. Flour Whiteness

Flour whiteness was an important indicator of wheat flour quality and an important criterion for classifying flour grades. Among the varieties (lines) (Figure 1), there were 10 with higher flour whiteness values than Calibration plate (whiteness 77.0), and 2 of them namely LHSJ 157 and LHSJ 156 had higher whiteness value than 80.0, whiteness value was 81.20 and 83.05 respectively. And another 5 new varieties (lines) had higher whiteness value than 78.0, including Jimai 0435, Jimai 5172, Jimai 40, Jimai 805, Jimai 899, etc. The whiteness values were 79.35, 78.95, 78.70, 78.60 and 78.35 respectively (Table A1).

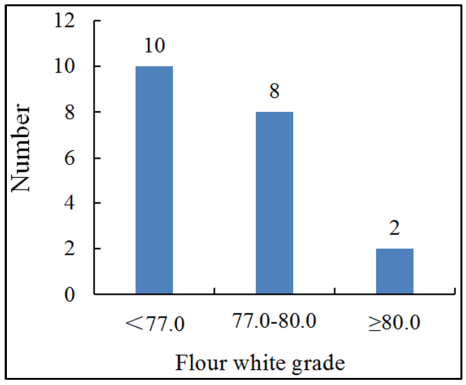

Figure 1. *Flour whiteness distribution of varieties (lines).*

3.1.2. Grain Protein Content

Grain protein content is an important indicator for quality evaluation of wheat varieties. Among the new varieties (lines) tested (Figure 2), there were 8 with the protein content reached the strong gluten standard (≥14.0%) of GB/T17320-2013, and 10 reached the standard for medium and strong gluten (≥13.0%). Among the 8 strong gluten varieties (lines), there were 1 be singled out, namely Jimai 6174, for its grain protein content reaching 16.0%, and other 2 namely Jimai 0435 and Jimai 5177 with higher grain protein content than 15.0% (Table A1).

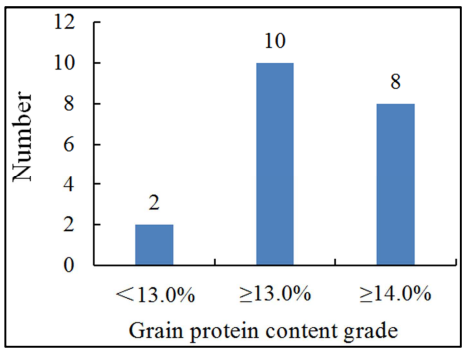

Figure 2. *Grain protein content distribution of varieties (lines).*

3.1.3. Wet Gluten Properties

Wet gluten content and gluten index are important indicators to identify the quality of wheat flour, reflecting the quantity and quality of protein. The test results of new varieties (lines) were shown in Figure 3 and attached table 1. There were 7 varieties with the wet gluten content reached the strong gluten standard (≥30.0%) of GB/T17320-2013, of which 1 line with the wet gluten content was as high as 47.19%, namely Jimai 6174, its gluten index was only 45.79%, while the dry gluten value of 100g flour was as high as 16.05g, indicating that Jimai 6174 has high amount of protein, which was consistent with its high grain protein content (16.0%). While only 1 variety with the gluten index was higher than 85%, namely Jimai 55. There were 5 varieties with the wet gluten content reaching the level of medium-strength gluten (≥28.0%), of which 2 varieties had a gluten index above 95.0%, namely Jimai 0435 and Jimai 106, indicating that the two varieties had high quality of grain protein. There were 8 varieties (lines) with the wet gluten content reaching the level of medium gluten (<28.0%), and 5 with the gluten index were higher than 90.0%, including Jimai 5177, Jimai 5022, Jimai 8365, LHSJ 157 and LHSJ 156, indicating the quality of grain protein of these five new varieties (lines) were high.

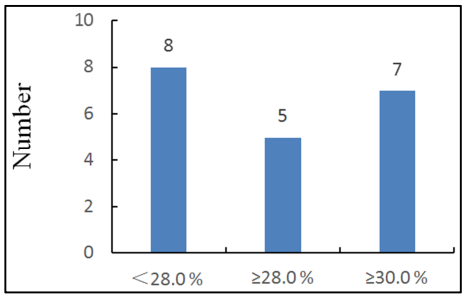

Figure 3. *Distribution of wet gluten content of varieties (lines).*

3.1.4. Dough Rheological Properties

Dough rheological properties are the main factors affecting the quality of food processing, and water absorption, stability time, maximum extensile resistance, extensibility and extensile area are important indicators for evaluating wheat quality. The analysis of dough rheological properties of the new varieties (lines) was shown in Figure 4 and attached table 1. There were 12 lines whose stability time was greater than 10.0min. Among which, the longest stability time was 40.3 min, namely Jimai 0435, and other 4 lines with stability time exceeded 30.0 min, including Jimai 5022, Jimai 8365, LHSJ 156 and Jimai 106. While 10 lines with water absorption was higher than 60.0%, and the highest was 65.0%, namely Jimai 5198. For extensile properties, except for Jimai 5172, the maximum extensile resistance of the tested varieties was greater than 500BU, the extension length was longer than 120mm, and the area was greater than 100cm^2. While for Jimai 106 and Jimai 0435, the maximum extensile resistance, extensibility and extensile area were 809 and 803BU, 182 and 159mm, and 109 and 166cm^2, respectively. In summary, four new varieties (lines) including Jimai 106, Jimai 0435, LHSJ 157 and Jimai 55 showed excellent dough rheological properties.

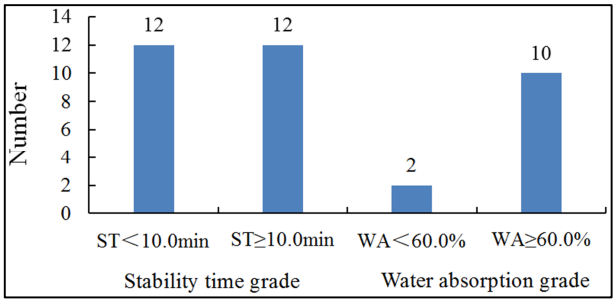

Figure 4. *Stability time and water absorption distribution of varieties (lines).*

3.2. Food Quality Characteristics of New Varieties (Lines)

3.2.1. Bread Quality Characteristics

The bread processing quality of the new varieties (lines) were evaluated, and the results were shown in Figure 5 and attached table 2. Twelve lines had excellent bread quality with the total score point higher than 85.0, and the average bread neck length was 21.32mm. Four lines had good quality grades, that is, the total score point was higher than 80.0, and the average bread neck length was 16.66mm. And for the others, the total score point of bread quality was lower than 70.0, and the average bread neck length was lower than 10.84mm. As for those 12 varieties (lines) with excellent bread quality, there were 6 lines with bigger bread volume than 900ml, and 9 lines with longer bread neck length than 20.35mm.

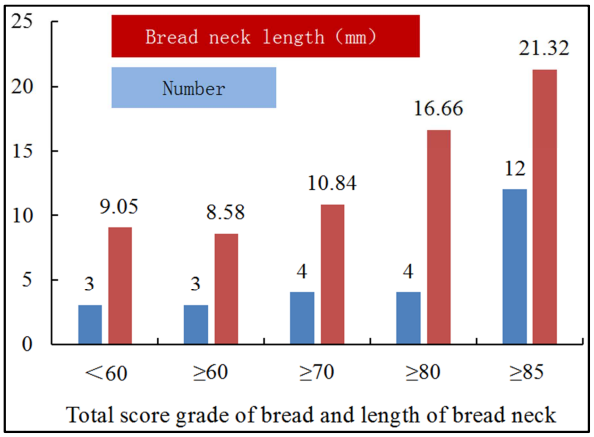

Figure 5. *Distribution of bread quality.*

In summary, varieties including Jimai 0435, Jimai 106, Jimai 40, Jimai 5022, Jimai 5177, Jimai 55, Jimai 8365, LHSJ 156, LHSJ 157, Jimai 108, Jimai 117 and Jimai 379 had excellent bread quality and could be used as special wheat for bread.

3.2.2. Steamed-Bread Quality Characteristics

The steamed-bread quality evaluation of these new varieties (lines) (Figure 6, Table A2) showed that only 4 had the quality reached the excellent grade, its total score was higher than 80.0, and 5 had the quality reached the good grade, and the total score was higher than 77.0, and the others belonged to the general grade or below. Moreover, for the excellent grade, all evaluation indicators performed well.

The mean value was used to analyze the significant differences in the evaluation scores of steamed-bread among four grades of excellent, good, fair, and poor (Table 1). It was found that the internal structure score and the total score were significantly different among the 4 grades, and the total score increased significantly with the increase of the internal structure score, and the correlation analysis found that there was a very significant positive correlation between the two. The scores difference of epidermal structure, elongation, elongation score and odor among the four grades were not significant. And the scores of shape, height, elasticity and specific volume were not significantly different, which showed no difference between the excellent, good and general grades, but significant difference between these three grades and the poor grade. The scores of color, tenacity and viscosity were not significantly different between adjacent grades, while the indicator scores of the excellent and good grades were significantly higher than those of the poor grade.

In summary, varieties such as Jimai 55, Jimai 6174, LHSJ 157 and Jimai 106 showed excellent steamed-bread processing quality, which could be used as special wheat for making special flour for steamed-bread.

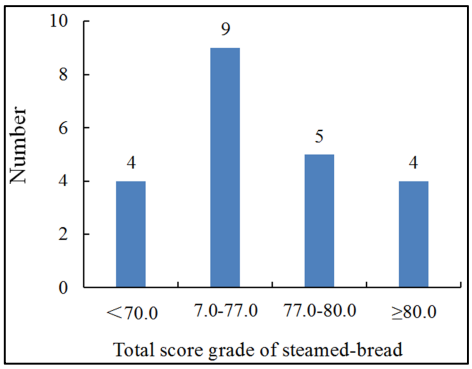

Figure 6. *Quality distribution of steamed-bread.*

Table 1. *Significant difference analysis of evaluation indexes of steamed-bread quality.*

Grade	Viscosity	Odor	Specific volume	Elongation	Specific volume score	Elongation score	Total score
Excellent	7.8a	4.6a	3.0a	1.7a	14.8a	4.8a	81.7a
Good	7.5a	5.0a	2.8ab	1.7a	14.7a	4.8a	78.5b
General	6.8ab	4.5a	2.7b	1.6a	13.5a	4.9a	73.8c
Poor	6.0b	4.8a	2.3c	1.8a	10.1b	4.6a	59.5d

Table 1. *Continued.*

Grade	Shape	Color	Epidermal structure	Height	Elasticity	Internal structure	Tenacity
Excellent	8.0a	7.8a	6.5a	57.2a	7.8a	11.5a	8.3a
Good	7.4a	7.2ab	6.8a	57.3a	7.3a	9.8b	8.0ab
General	7.3a	7.2abc	6.7a	57.5a	7.1a	8.3c	7.6bc
Poor	5.8b	6.0c	5.9a	50.9b	4.5b	4.8d	7.3c

Notes: Different letters indicate a significant level of 0.5, the same below.

3.2.3. Noodle Quality Characteristics

The evaluation of the noodle processing quality of the new varieties (strains) found that (Figure 7, Table A2), there were 6 noodles with a total score above 80.0, and its quality belong to excellent level, two noodles with a total score between 77.0 to 79.9, and its quality belong to general level, and for the rest, the total scores were below 70.0, and the noodle quality belong to poor level. There were some differences in the scores of evaluation indicators among the above three grades (Table 2). The scores of the appearance performance in the excellent and general grades were significantly higher than those in the poor grades. The scores of the three evaluation indicators such as hardness, viscoelasticity and smoothness in the excellent grades were significantly higher than those in the general and poor grades. While the total score showed significant difference among the three grades. All these indicated that the noodle quality of the 6 new varieties (lines), including Jimai 0435, Jimai 8365, Jimai 6001, and Jimai 4227, Jimai 106 and LHSJ 156, with a total score above 80.0 was significantly better than that of the others. Thus these 6 varieties (lines) could be suitable for special wheat for noodle processing.

Table 2. *Significant difference analysis in the evaluation indicators of noodle quality.*

Grade	Color	Performance	Hardness	Viscoelasticity	Smoothness	Taste	Total score
Excellent	18.17a	7.17ab	17.33a	24.17a	12.33a	4.58a	83.75a
General	18.67a	7.67a	16.67b	20.67b	10.67b	4.50a	78.83b
Poor	18.05a	6.33b	15.40b	19.40b	10.20b	4.58a	73.96c

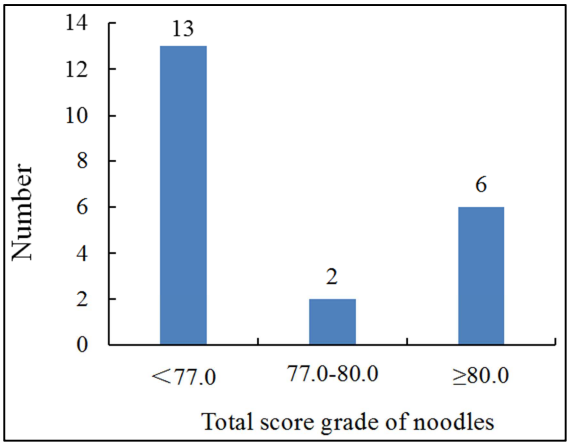

Figure 7. *Quality distribution of noodles.*

4. Discussion and Conclusion

In our country, the total supply of wheat grain is sufficient, but the production of high-quality special wheat is seriously insufficient. By the "Twelfth Five-Year Plan" period, the number of high-quality wheat varieties bred in Shandong Province and even the whole country was small, and the quality needed to be further improved [4-8, 13-16], furthermore, a shortage existed of high-quality wheat varieties that could truly meet the needs of processing enterprises. During the "Thirteenth Five-Year Plan" period, improving protein and gluten quality was regarded as the focus of wheat quality breeding, at the same time, attention was paid to the flour color improvement. Thus, the quantity and quality of high-quality varieties have been greatly improved and released [17, 18]. While the supply of commercial grains was still could not meet the needs of processing various special flours, about 8 million tons of wheat grains needed to be imported annually, mainly high-quality special wheat. Therefore, it was necessary and urgent to continue to strengthen the breeding, promotion and utilization of new high-quality special wheat varieties. In the past three years, selection and breeding of different types of wheat was strengthened, and a batch of new wheat varieties (lines) were participating different level trials. In this study, by systematic identification and evaluation of flour physicochemical properties and food processing quality, new varieties (strains) with excellent quality characteristics and excellent food processing properties were picked out. These varieties could be grouped into two categories, the dual-purpose type and the special-purpose type. Among them, the variety Jimai 106 had excellent quality of bread, steamed-bread and noodles, the strain LHSJ 156 and Jimai 8365, and variety Jimai 0435, had excellent quality of bread and noodles, the strain LHSJ 157 and variety Jimai 55 had excellent quality of bread and steamed-bread, all these varieties (strains) could be used as dual-purpose wheat. While varieties such as Jimai 5022, Jimai 40, Jimai 5172, Jimai 108, Jimai 117 and Jimai 379 had excellent bread quality, strain such as Jimai 6174 had excellent steamed-bread quality, strains such as Jimai 6001, Jimai 899 and Jimai 4277 had excellent noodle quality, all these varieties (lines) could be used as special wheat.

Table 3. *Correlation analysis between the extreme rise value of bread neck and the physical and chemical properties of flour and evaluation indexes of bread quality.*

Physical and chemical properties	R value	Evaluation indexes	R value
Gluten content	-0.523*	Volume	0.617**
Gluten index	0.834**	Volume score	0.630**
Dry gluten value	-0.314	Appearance	0.832**
Grain protein content	0.073	Core color	0.665**
Water absorption	-0.597**	Core texture	0.724**
Stability	0.563**	Texture structure	0.727**
Maximum resistance	0.568	Bread total score	0.767**
Elongation	0.687*		
Are	0.659*		

Note: * ** means 0.05, 0.01 significant level respectively.

Table 4. *Significant difference analysis of extreme value between different bread quality grades.*

Bread quality grade	Extreme value (mm)
Premium	21.32a
Excellent	16.66b
Medium	10.84c
Lowe	8.58c
Lower	9.05c

Among the scoring standard of bread baking quality, the size of the bread neck is one of the important factors for the evaluation of bread appearance. The score is determined by qualitative expression without quantitative indicators (National Standard GB/T14611-2008). In this study, the correlation analysis between the increased length of bread neck and the physical and chemical properties of flour and the evaluation indexes of bread quality found that (Table 3), the increased length of bread neck was significantly positively correlated with gluten index and stability, and was positively correlated with elongation and area, furthermore, it was extremely significantly positively correlated with the evaluation indexes of bread quality. All these indicated that the increased length of bread neck could be used as an index for evaluating bread quality. Further significant difference analysis was performed on the increased length of bread neck of the 5 grades (Table 4),

and found that the bread neck increased significantly with the increase of the total bread score. The increased length of bread neck of the premium grade is significantly higher than that of the excellent grade, and that of the excellent grade is significantly higher than that of the medium and lower grades. On the contrary, with the increase of the increased length of bread neck, the bread quality became better. When the increased length of bread neck was above 16.0mm, the bread quality reached the excellent level, and when it was above 20.35mm, the bread quality reached the premium level. Therefore, the increased length of bread neck could be used as a quantitative index for the evaluation of bread quality. When the increased length of bread neck was assigned a certain score, the bread quality grade could be preliminarily judged.

Acknowledgements

The authors acknowledge Key R & D Program of Shandong Province (Agricultural Variety Improvement Project) (2021LZGC009), Key R&D Program of Shandong Province (Major Technological Innovation Project) (2020CXGC0108053) for provided financial and support, Research and Industrialization of Key Technologies for Brand Development of "SAAS Big Steamed-Bread" (SHJB2021-02).

Appendix

Table A1. *Quality Characteristics of New Varieties (Lines).*

Varieties	Whiteness (%)	14%Glutein content (%)	Glutein index (%)	Dry glutein value (g)	Grain protein content (dry bases) (%)	Water absorption (%)	Stability (min)	Maximum resistance (BU)	Elongation (mm)	Are (cm^2)
LHSJ156	83.05	27.82	90.23	10.60	14.1	57.1	34.6	686	142	127
LHSJ157	81.20	26.85	97.79	10.25	13.7	61.3	15.9	731	166	158
Jimai0435	79.35	29.25	96.79	10.70	15.0	62.4	40.3	803	159	166
Jimai106	75.55	29.82	95.86	10.40	14.8	62.4	33.0	809	182	190
Jimai38	76.85	34.90	58.20	12.65	13.9	65.4	4.2	-	-	-
Jimai40	78.70	27.52	79.89	9.65	13.3	64	17.4	629	140	118
Jimai4227	77.35	31.90	48.45	10.65	13.7	64.5	6.0	-	-	-
Jimai5022	77.95	27.43	98.03	11.75	14.0	59.6	39.8	736	153	148
Jimai5172	78.95	28.82	77.85	10.40	13.6	63.5	10.6	441	139	85
Jimai5177	77.70	24.99	99.41	9.70	15.0	62	12.2	-	-	-
Jimai5189	76.95	31.34	62.58	10.90	13.8	64.8	7.9	-	-	-
Jimai5198	75.75	30.65	75.84	10.65	13.2	65	16.7	597	127	102
Jimai52	76.85	27.31	84.68	9.66	13.0	64.7	14.6	526	141	101
Jimai55	76.20	31.36	87.19	12.80	14.5	63.6	27.3	612	165	135
Jimai5789	76.20	29.30	64.99	10.25	13.1	63.8	6.8	-	-	-
Jimai6001	75.95	35.66	56.89	12.55	14.7	68.1	4.8	-	-	-
Jimai6174	71.75	47.19	45.79	16.05	16.0	69.8	3.0	-	-	-
Jimai805	78.60	26.68	74.40	9.40	12.7	63.5	9.7	-	-	-
Jimai8365	74.85	24.62	98.22	9.20	13.8	61	39.3	-	-	-
Jimai899	78.35	29.07	66.27	10.25	12.8	64.3	6.8	-	-	-
Jimai108	-	-	-	-	-	63.1	6.68	-	-	-
Jimai117	-	-	-	-	-	62.8	9.19	-	-	-
Jimai161	-	-	-	-	-	64.6	5.81	-	-	-
Jimai379	-	-	-	-	-	60.6	9.87	-	-	-

Table A2. *Quality of Steamed Bread, Noodles and Bread of New Varieties (Lines).*

Varieties (Lines)	Bread extreme value (mm)	Bread total score	Steamed-bread total score	Noodle total score
Jimai0435	20.75	95.0	72.6	86.5
Jimai106	25.31	95.0	81.0	80.5
Jimai38	8.98	60.2	62.5	67.5
Jimai40	16.60	95.5	78.9	76.5
Jimai4227	9.58	78.3	78.8	84.5
Jimai5022	20.35	92.3	56.8	72.5
Jimai5172	10.16	82.9	74.1	74.5
Jimai5177	21.84	95.5	78.7	75.5
Jimai5185	9.97	55.2	79.7	76.5
Jimai5189	9.55	66.1	60.6	79.5
Jimai5198	18.73	83.5	74.2	75.5
Jimai52	20.93	82.5	76.9	76.5
Jimai55	27.92	85.3	82.4	74.5
Jimai5789	11.81	56.6	77.4	70.5
Jimai6001	10.87	72.2	71.9	85.0
Jimai6174	7.22	62.0	81.8	73.0

Varieties (Lines)	Bread extreme value (mm)	Bread total score	Steamed-bread total score	Noodle total score
Jimai805	16.82	81.1	74.9	74.0
Jimai8365	16.05	91.1	70.1	85.5
Jimai899	12.87	79.2	75.8	77.5
LHSJ156	19.81	87.8	76.0	80.5
LHSJ157	22.03	93.0	81.7	71.5
Jimai161	10.07	72.7	-	-
Jimai108	19.66	85.7	-	-
Jimai117	21.87	92.7	-	-
Jimai379	23.72	88.1	-	-

References

[1] LI Nana, PU Yanyan, KONG Weiguo, GONG Yongchao, JIA Wenbin, XIN Fugang, YU Yanli, DING Hanfeng. Advances in the Study of Protein Quality Traits and Main Influencing Factors of Wheat in China. Chinese Agricultural Science Bulletin, 2015, 31 (15): 140-145.

[2] HE Zhonghu, YAN Yueming, ZHUANG Qiaosheng, ZHANG Yan, XIA Xianchun, ZHANG Yong, WANG Desen, XIA Lanqin, HU Yingkao, CAI Minhua, CHEN Xinmin, YAN Jun, ZHOU Yang. Establishment of Quality Evaluation System and Utilization of Molecular Methods for the Improvement of Chinese Wheat Quality. Scientia Agricultura Sinica, 2006, 39 (6): 1091-1101.

[3] HE ZhongHu, XIA XianChun, CHEN XinMin, and ZHUANG QiaoSheng. Progress of Wheat Breeding in China and the Future Perspective, Acta Agronomica Sinica, 2011, 37 (2): 202-215.

[4] LIAO Pingan, GUO Chunqiang, JIN Wenkui. Study on the Quality Status of Wheat Varieties (Strains) Grown in the South of the Huang-huai Wheat Region, Journal of Triticeae Crops, 2003, 23 (4): 139-140.

[5] QI Linjuan, HU Xuexu, ZHOU Guiying, WANG Shuang, LI Jingmei, LU Wei, WU Lina, LU Meibin, SUN Lijuan, YANG Xiulan, SONG Jingke, WANG Bujun. Analysis of Wheat Protein Quality in Main Wheat Producing Areas of China from 2004 to 2011, Scientia Agricultura Sinica, 2012, 45 (20): 4242-4251.

[6] ZHAO Junye, YU Zhenwen. The Status and Development Strategy of Quality Wheat Production for Specific End- use in China, Chinese Agricultural Science Bulletin, 2006, 22 (3): 171-174.

[7] SONG Hongyuan, ZHANG Hengchun, LI Jie, WU Zhigang. Loss of Harvest China's Grain -A Case Study of Wheat in Henan Province. Journal of Huazhong Agricultural University (Social Sciences Edition), 2015, (4): 1-6.

[8] WANG Meifang, LEI Zhensheng, ZHANG Jiawei, WU Zhengqing, LEI Tianyu, XU Fuxin, YANG Pan, LIU Jiaping, LI Wei. Yield and Quality Analyais of Strong-Gluten Wheat in Huang-Huai Winter Wheat Region, Journal of Triticeae Crops, 2017, 37 (1): 94-101.

[9] ZHAO Zhendong, LIU Jianjun, XU Hengyong, SONG Jianmin, LIU Aifneg, WU Xiangyun. A New Noodle Wheat Variety Jimai19 with High Yield Potential. Shandong Agricultural Sciences, 2001, 4: 36.

[10] SONG Jianmin, LIU Jianjun, LIU Aifeng, LI Haosheng, WU Xiangyun, ZHAO Zhendong. Relationship between Dough Rheological and Starch Properties of Jimai 19 and Its Noodle Quality, Journal of Triticeae Crops, 2004, 24 (1): 15-17.

[11] LIU JianJun, ZHAO ZhenDong, HE Zhonghu, SONG Jianmin, LI Haosheng, LIU Aifeng, LI Genying, CHENG Dungong. Breeding and Application of Strong-gluten Wheat Cultivar Jimai 20 with Good Bread and Noodle Quality.

[12] ZHAO Zhendong, LIU Jianjun, LIU Aifeng, SONG Jianmin, XU Hengyong, WU Xiangyun. Breeding and industrial development of a new high-yield wheat variety Jinan 17 for bread and steamed bread. Research progress of wheat breeding in China, edited by He Zhonghu and Zhang Aimin, Beijing: China Science and Technology Press, 2002, p 177-182.

[13] SONG Jiajing, CHEN Jie, BAI Dong, JIN Yan, ZHAO Lishang, ZHU Tongquan. Correlation analysis of yield and quality characters in 33 new bread wheat lines. Journal of Henan Institute of Science and Technology: Natural Science Edition, 2016, 44 (3): 1-6.

[14] HUANG Chengyan, CHI bin, QU Huiying, LU Jianhua, GUAN Yanan, CHU Xiusheng, SUI Xinxia, LI Genying. Analysis on quality status of wheat cultivars in Shandong Province, Shandong Agricultural Sciences, 2004 (2): 12-15.

[15] ZHAO Qian, LIU Zhaoye, JIANG Hongming, XIN Qingguo, LI Linzhi. Studies so Quaility Characters of Winter Wheat Varieties (Lines) in Regional Trials of Shandong Province. Shandong Agricultural Sciences, 2009 (4): 24-28.

[16] SUN Zhengjuan, QU Yi, CHENG Dungong, WANG Canguo, LI Haosheng, SONG Jianmin, CAO Xinyou, LU Jianhua, LIU Aifeng, Analysis on Quality Status of New Wheat Varieties (Lines) Selected in Shandong During the Period of 12th Five-Year. Shandong Agricultural Sciences, 2009 (4): 24-28.

[17] SHEN Yesong, WANG Xin, GU Zhengzhong, YANG Zibo, ZHAN Qiuwen. Quality analysis of 296 wheat varieties from the Huang-Huai wheat region planted in Huaibei area of Jiangsu. Journal of Zhejiang Agricultural Science., 2018, 30 (10): 1617-1623.

[18] HU Xuexu, SUN Lijuan, ZHOU Guiying, WU Lina, LU Wei, LI Weixi, WANG Shuang, YANG Xiulan, SONG Jingke, WANG Bujun. Quality Variation of National Tested Varieties in Northern Winter Wheat Region and Yellow-Huai River Valley Winter Wheat Region from 2000 to 2015. Scientia Agricultura Sinica, 2016, 49 (24): 4677-4686.