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Analysis Of Nutritional Quality And Processing Characteristics Of High-Quality Strong Gluten Wheat Flour

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Abstract
The nutritional quality and processing quality of high-quality strong gluten wheat flour were analyzed in this study. In terms of nutritional quality, the contents of wet gluten, protein, starch, and ash were determined, and the frequency distribution was mostly normal, and the sedimentation value was skewed. The peak viscosity and recovery value in the pasting characteristics are normally distributed, the pasting temperature is bimodal distribution, the water absorption rate in the silty characteristics is normal distribution, the weakening degree, dough formation time and consistency are skewed distribution, and the stabilization time has a special shape. The maximum resistance, 50 mm resistance, and elongation showed a skewed distribution. Different varieties of wheat flour showed differences in each index.

Keywords: *high quality strong gluten wheat flour, nutritional quality, processing quality, Shandong wheat*

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I. Introduction

Wheat is the third largest grain crop in China, and the improvement of wheat yield is of great significance to global food security. Currently, the domestic production of high quality strong gluten wheat is insufficient to satisfy market demand, necessitating the annual importation of 3-4 million tons of high quality strong gluten wheat for wheat flour blending. It is of great significance to carry out the research and application of high quality strong gluten wheat to improve the quality and efficiency for food security. Shandong Province is the main producing area of high-quality wheat in China. The sown area of high-quality wheat extends 3.67 million hectares, ranking the second in China. However, the sown area of strong gluten wheat, which is imperative for the production of high-end special flour, is less than 200 thousand hectares, representing approximately 3-5% of the total. In this study, seven high quality strong gluten wheat varieties cultivated in Shandong Province were used as experimental materials. The quality traits of wheat flour from different production areas were analyzed and comprehensively evaluated under identical cultivation conditions, in order to understand the current situation of high quality strong gluten wheat flour quality cultivated in Shandong Province and provide a basis for the future wheat quality improvement and industrial development within the region.

In this study, the nutritional quality and processing quality of high quality strong gluten wheat flour were comprehensively and systematically analyzed, and the differences of each index among different varieties were examined. Through the analysis of nutrition and processing quality of high quality strong gluten wheat flour, the understanding of the inherent law of nutrition composition and processing characteristics was deepened. According to the nutritional quality and processing quality characteristics of various wheat flour varieties, food processing enterprises can accurately select suitable wheat varieties, optimize processing technology, and improve product quality, which is helpful to give full play to the advantages of high-quality strong gluten wheat resources, promote the high-quality development of the food industry, and meet consumers' demand for high-quality food. At the same time, for the wheat planting industry, the results also provide a reference direction for the selection of high-quality wheat varieties with strong gluten, and promote the optimization of agricultural industry structure.

II. Materials And Methods

Materials

The tests materials were seven varieties of wheat flour, including Jimai22, Jimai38, Jimai44, Taikemai33, Yannong999, Zhongmai578, collected in summer 2022 and made into wheat flour.

Tests Methods

The nutritional quality and analytical indicators included wet gluten content (GBT5506.1), protein content

(GB 5009.5), starch content (GBT20378), moisture content (GB 5009.3), ash content (GB5009.4), falling number (GBT21119), rheological characteristics (GBT14614), pasting characteristics (GB/T24853), and extensograph characteristics (GBT14615).

Data Analysis

The data were processed and analyzed using Excel 2019 and Origin 2022 software.

III. Results And Analysis

Nutritional Quality Analysis

Wet gluten, a viscoelastic substance, is predominantly composed of two protein components of wheat, glutenin and gliadin, which are hydrated rather than being dehydrated. Wet gluten content, protein and starch content are important indicators for enterprises to measure their quality. As seen from Fig. 1., Jimai70, with a wet gluten content of 34.51%, displayed the highest value among the varieties. Tyco wheat 33 exhibited the highest protein content, reaching 14.24%. Yannong999, which had the highest starch content at 81.58%, also displayed the lowest wet gluten and protein contents, at 29.26% and 12.79%, respectively. While Jimai44 had the lowest starch content, recoded at 80.23%.

A frequency histogram is an accurate graphical representation of the distribution of numerical data. It is an estimate of the probability distribution of a continuous variable and can reflect the overall distribution of the sample. The frequency distribution of wet gluten content, protein content, starch content, and ash content basically showed a normal distribution and showed continuous variation. The frequency distribution of settlement values is a skewed histogram (Fig. 2). The content of wet gluten varied greatly among varieties. Wheat flour with a higher wet gluten content (e.g. 34.51% of wheat 70) is more advantageous for food processing that requires high gluten, such as bread making. High wet gluten content is capable of forming a strong gluten network, which is essential for maintaining the dough's shape during fermentation and baking, giving the bread desirable volume and elasticity. However, in the case of foods with low gluten requirements, such as cakes, wheat flour with low wet gluten content (such as 29.26% of Yannong999) may be more suitable to avoid overly tough dough and ensure the cake retains its desired soft texture and taste.

Protein is one of the key factors affecting the quality of wheat flour. Taikemai33, with the highest average protein content of 14.24%, is particularly advantageous for food processing that requires a strong gluten network and therefore improves the strength and elasticity of dough. In noodle processing, proper protein content can lead to a better chewiness and more elastic taste. For example, the higher protein content of wheat flour can prevent the noodles from breaking during stretching and provide a smooth taste and firm texture.

The highest average starch content of 81.58% was recoded in Yannong999. The General pasting characteristics of starch in food processing have an important impact on product quality. In the process of making steamed bread, wheat flour with high starch content can form a loose structure inside the steamed bread and increase the softness and volume of the steamed bread due to starch gelatinization. At the same time, the difference in starch content of different varieties of wheat flour will also affect the aging speed of food. High starch content may be more prone to aging during storage, which needs to be considered in processing and storage technology.

Although ash is relatively low in content compared to other components, it can reflect the purity and mineral content of wheat flour. A higher ash content demonstrates that the wheat flour contains more impurities or minerals, which may have some side effects on the color, flavor and processing characteristics of the food. For example, it is necessary to choose wheat flour with low ash content to ensure the white appearance of the bread when making high-grade white bread.

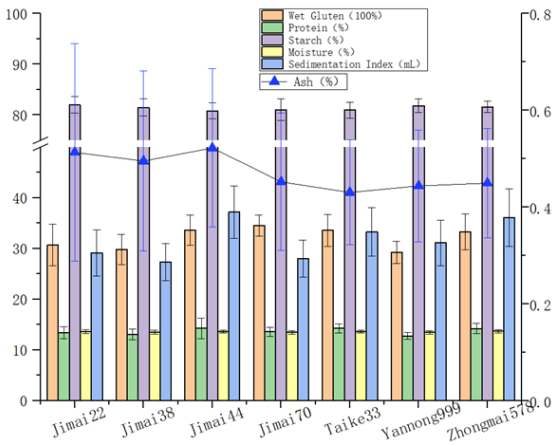

Fig. 1 Nutrient Content Of Wheat Flour

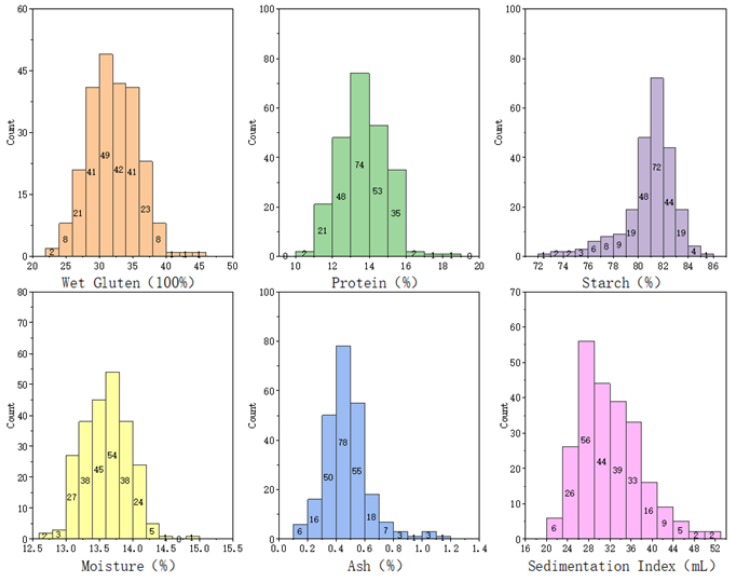

Fig.2 Frequency Distribution Of Nutrients Content Of Wheat Flour

Processing quality analysis

(1) General pasting characteristics

Some of the main general pasting characteristics of wheat flour, such as gelatinization temperature, peak viscosity, retention strength, recovery value, etc., all affect the appearance and eating quality of bread, noodles, steamed bread and other foods to a certain extent. The viscosity traits of wheat flour expressed by the peak viscosity could reflect the quality of different wheat varieties, and were significantly positively correlated with the elasticity, toughness and edible characteristics of different types of noodles.

The general pasting characteristics of wheat flours varied greatly among cultivars. The highest mean value of peak viscosity was Yannong999, and the lowest was Jimai38. Regarding the batch average viscosity, Yanong999 showed the highest value at its lowest point and Jimai22 showed the lowest value (as shown in Fig. 3). The frequency distribution of peak viscosity and recovery value was basically normal distribution, showing continuous variation. The gelatinization temperature showed a bimodal distribution (Fig. 4).

The characteristic of normal distribution of peak viscosity and recovery values indicates that there is a continuous range of variation in these two indices among different varieties of wheat flour. Wheat flour with high peak viscosity, such as Yannong999, has advantages in the production of food product that require good viscosity such as pastry (like glutinous rice dumplings), where high viscosity allows the filling to better bond to the outer skin. Recovery value is related to the aging of food. Foods made from wheat flour with lower recovery value show a slower aging speed during storage and can maintain a better taste, which is of great significance for foods that need to be stored for long period of time , such as dry foods.

The phenomenon of bimodal distribution of gelatinization temperature indicates that the gelatinization behavior of different wheat varieties is quite different. In food processing, wheat flour with a lower gelatinization temperature can achieve starch gelatinization at a lower temperature, which is beneficial for energy saving and reducing the destruction of other heat-sensitive components in food. For example, when making instant foods, wheat flour with a lower gelatinization temperature can allow the product to gelatinize faster during hot water brewing, improving the convenience and taste of the product.

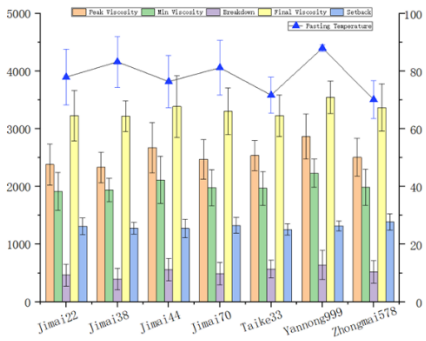

Fig. 3 General Pasting Results

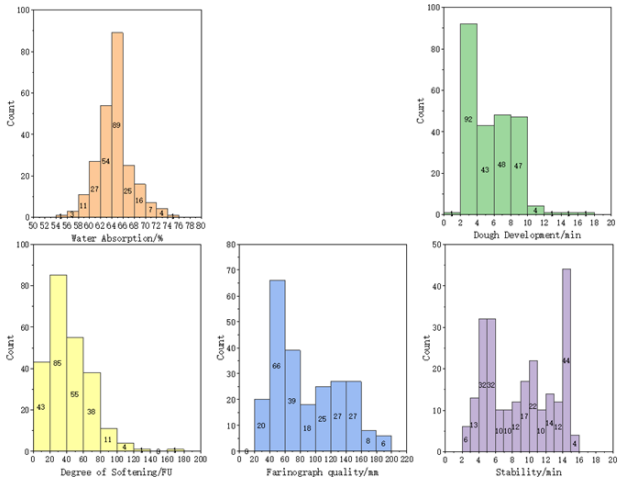

Fig.4 Frequency Distribution Of General Pasting Results

(2) Rheological characteristics

Different wheat foods have different quality requirements for wheat flour as raw material, among which the silty characteristics of wheat flour is one of the main reference indexes. The silty characteristics are generally measured by a silty meter, in which wheat flour forms a dough according to a predetermined requirement. The silty meter draws a silty curve according to the mechanical characteristics of the formed dough. The silty curve can directly reflect the silty characteristics of wheat flour, and the important parameters include water absorption rate, formation time, stability time, and weakening degree. In the process of wheat flour kneading with water, the proteins absorb water and expand, and the molecules are connected to each other to form a continuous three-dimensional network structure, thus giving the dough viscoelasticity and a certain fluidity, which is generally referred to as dough rheology. Dough rheology is an important index to evaluate the processing quality of flour. It is a comprehensive performance of kneading resistance and viscoelasticity after wheat flour is added to water to form dough, which determines the processing quality of final products such as bread, steamed bread and noodles.

The wheat variety with the longest dough formation time was Taikemai33 with 7.34 minutes and the shortest was Jimai38 with 3.87 minutes. Among the varieties, Jimai44 had the longest mean stabilization time of 13.23 minutes, while Jimai22 had the shortest mean stabilization time of 5.21 minutes (as shown in Fig. 5). Water absorption followed a normal distribution, reflecting a continuous variation. The frequency distributions of weakening degree, dough formation time, and consistency were skewed histograms. The stabilization time showed a zigzag shape (as shown in Fig. 6).

The normal distribution of water absorption indicates that different varieties of wheat flour have certain regular changes in the ability to absorb water. The high water absorption capacity of wheat flour indicated that more water was needed to add during dough preparation, which is crucial for regulating the hardness and processing characteristics of dough. When making different types of pasta, wheat flour with appropriate water absorption can be selected according to the need. For example, when making hand-made ramen noodles, wheat flour with higher water absorption may be needed to make it easier to adjust the softness and hardness of the dough during the kneading process, resulting in more uniform and delicate ramen noodles.

Wheat dough with a long dough formation time, such as 7.34 min for Taikemai33, demonstrating that more stirring time during processing to develop a proper dough structure was required. The wheat flour with low weakening degree provides better dough stability during processing, and is suitable for long-term processing or food that requires multiple processing operations, such as the production of quick-frozen dumpling skin. The consistency affects the fluidity and operability of the dough. For the processing of different shapes of pasta (such as the production of flower rolls and dumpling skins have different requirements for consistency), it is necessary to choose the appropriate consistency of wheat flour according to the requirements of the product.

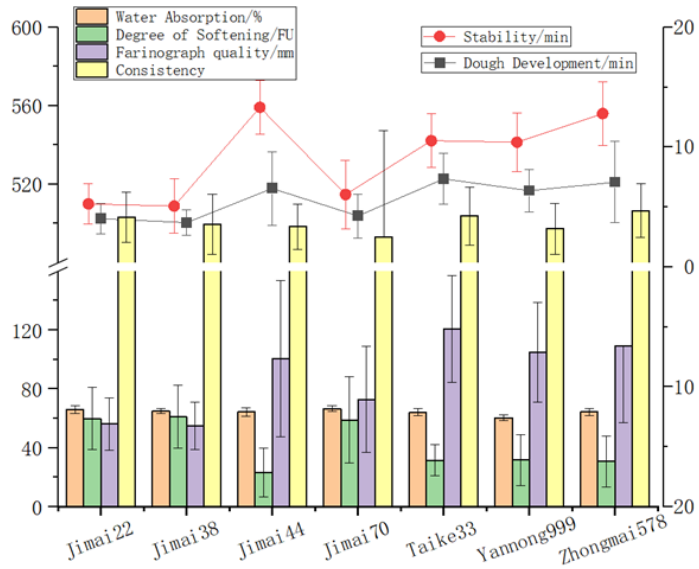

Fig.5 Farinograph Results

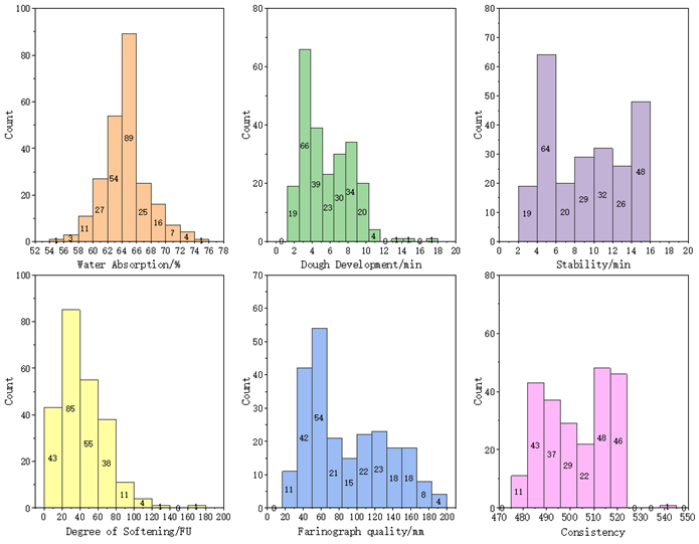

Fig.6 Frequency Distribution Of Farinograph Results

(3) Extensograph characteristics

Energy, maximum tensile resistance and extensibility are the most important indexes for accessing the tensile characteristics of dough. These parameters not only can fully express the elasticity and toughness of dough, but also serve to distinguish the strength of wheat gluten. The content and quality of gluten protein significantly influence the tensile characteristics of dough and are decisive factors in determining the quality of wheat in secondary processing applications. As observed in the tensile characteristics depicted in Fig.7, the wheat variety exhibiting the largest elongation was 213 mm, while the variety with the smallest elongation was Jimai22, at 118 mm. The wheat variety with the highest tensile resistance was Jimai44, which was 772 EU, and the smallest was Jimai38,262 EU. The frequency distributions of maximum resistance, 50 mm resistance, and elongation are skewed histograms (Fig. 8).

The skewed distribution observed in the extensograph characteristics index indicates the differences in dough elasticity and toughness among wheat dough of different cultivars. Wheat dough with high maximum and 50 mm resistance, along with moderate extensibility, such as Jimai44, are suitable for producing foods that require good elasticity and toughness, like French baguettes. However, in the case of foods that require a certain degree of extensibility but not high elasticity, such as pancakes, it is advisable to select wheat flour with higher extensibility and lower resistance.

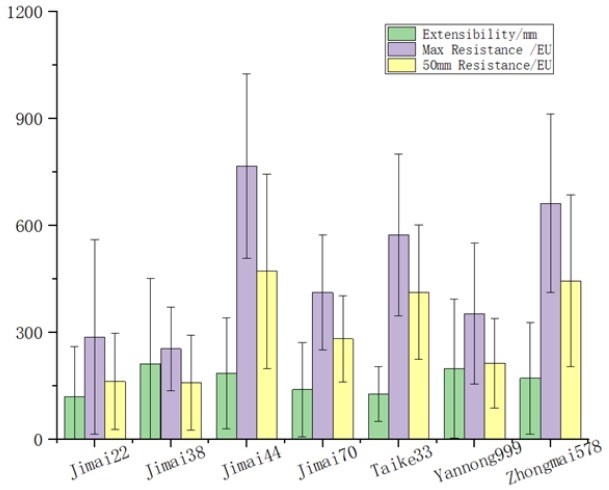

Fig. 7 Extensograph Results

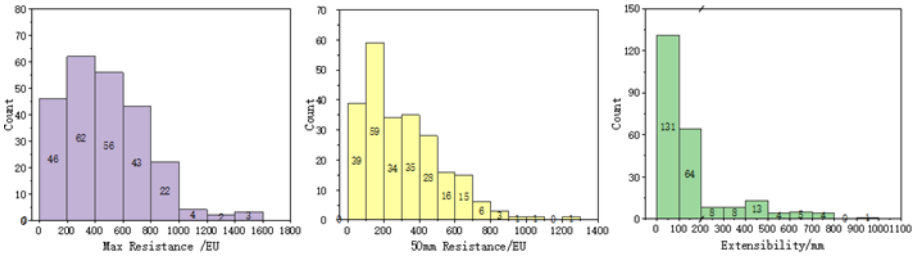

Fig. 8 Frequency Distribution Of Extensograph Results

In conclusion, according to the processing requirements of different foods, food processing enterprises can make accurate choices based on the quality characteristics of different varieties of wheat flour in this study. For example, for enterprises producing high-quality bread, varieties such as Jimai70 and Taikemai33 with high wet gluten content and protein content, long dough formation time and stability time, and good stretching characteristics can be preferred. For companies that produce low-gluten foods such as biscuits and cakes, a variety with relatively low wet gluten and protein content such as Yannong999 can be considered.

In comprehensive food processing enterprises producing various types of food, it is essential to rationally matched different wheat flour varieties based on the proportion and demand of different products to optimize both economic efficiency and product quality. For example, in the production of bread and cake enterprises, high-gluten wheat flour and low-gluten wheat flour can be mixed in a certain proportion to make some cakes with moderate gluten requirements.

IV. Conclusion

The results of this study on high quality strong gluten wheat flours showed that there were significant differences in nutritional and processing qualities among wheat flours of different cultivars. In terms of nutritional quality, the content distribution of wet gluten, protein, starch and ash had their own characteristics. In terms of processing quality, the silt characteristics and tensile characteristics of different varieties were significantly different, such as peak viscosity, dough formation time and elongation. The differences and distribution rules of these quality characteristics provide a scientific basis for variety selection and process adjustment of high-quality strong gluten wheat flour in food processing, which is helpful to better use of high-quality strong gluten wheat resources and improve the quality of related products.

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