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# Variation and trends in dough rheological properties and flour quality in 330 Chinese wheat varieties

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ABSTRACT

The objective of this study was to investigate variation and trends in dough rheological properties and flour quality traits in 330 Chinese wheat varieties. The dough rheological properties of development time (DT), stability time (ST), and farinograph quality number (FQN) were evaluated, as well as the flour quality traits of protein (PC), wet gluten content (WGC), and sedimentation value (SV). The coefficients of variation of DT (40.5%), ST (58.1%), and FQN (42.4%) were higher than those of PC (9.1%), WGC (10.1%), and SV (15.3%). Normal distributions were observed for the flour quality indices but not for the rheological parameters. SV was strongly correlated with the three rheological parameters and accordingly might be used as a primary indicator for dough rheological property evaluation. Our results showed that there has been marked improvement in dough rheological properties for Chinese wheat varieties released since 1986, while flour quality has remained stable.


## 1. Introduction

Wheat, one of the principal cereal crops in China, is used in a variety of products including noodles, steamed breads, dumplings, pancakes, breads, and biscuits. With an increasing concern for nutrition and taste of wheat products, there has been an increased demand for high-quality wheat varieties in the food industry and corresponding interest in wheat quality improvement. Quality improvement of wheat involves grain or flour quality, dough rheological properties, and end-use product quality. In the past several decades, dough rheological properties have increased in importance in wheat breeding [1], perhaps because they provide more direct information than grain or flour traits. Additionally, in wheat breeding programs, end-use quality of many breeding materials can't be directly determined, owing to limited seed quantities, and

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is often predicted by evaluation of dough rheological properties [2-5].

In recent years, wheat quality research has focused partly on correlations among flour and dough properties and end-use quality. Large variation in dough rheological properties among some wheat cultivars in China has been found in different end-use products, such as Chinese steamed bread, dry white Chinese noodles, pan bread, and fresh white noodles [6–8]. However, these studies do not represent a full evaluation of wheat quality among the numerous cultivars released in the long period from 1949 to 2010.

The trend of genetic improvement in wheat quality is also very important for wheat breeding. Breeding strategy may be guided by evaluation of genetic gain or loss of wheat quality. Fufa et al. [9] found that there had been a decrease in flour protein content but an increase in end-use quality in 30 hard red winter wheat cultivars released from 1874 to 2000 in Nebraska. Underdahl et al. [10] reported that protein content, flour-extraction yield, and dough character score of spring wheat cultivars released in 1968 did not vary significantly from cultivars released after 1968, although crumb color showed an increase overtime.

As a secondary center of diversity for wheat, China possesses abundant wheat genetic resources. Since the 1980s, studies of species diversity, genetic diversity, agronomic characters, and nutritional quality of wheat cultivars have been reported [11,12]. However, variation in flour and dough properties of different wheat varieties has remained poorly studied. The objective of this study was to evaluate variation and quality improvement trends in dough rheological properties and flour quality of wheat varieties released since 1949 in China.

## 2. Materials and methods

### 2.1. Wheat samples

A total of 330 wheat varieties with diverse origins, including leading commercial cultivars and elite advanced lines released since 1949, were provided by Prof. Lihui Li from the Resources Research Center of the Chinese Academy of Agricultural Sciences (CAAS), Beijing. The tested cultivars were sown in the 2010–2011 crop season at the wheat breeding station of the Institute of Crop Science, CAAS. The cultivars were divided into four different groups according to the release periods, as follows: period I, 1949–1976; II, 1977–1985; III, 1986–2000; and IV, after 2000. Each grain sample was tempered to a constant moisture content (14.5%) for 12 h and then milled in a Brabender Junior Laboratory mill (Brabender OHG, Duisberg, Germany).

### 2.2. Flour quality

Flour protein content (PC) was determined by near infrared reflectance spectroscopy following AACC method 39-11 [13]. Wet gluten content (WGC) was determined according to ISO standard 5531 [14] by a Glutomatic 2100 apparatus (Perten Instruments AB, Huddinge, Sweden). Sedimentation value (SV) was determined according to AACC method 44-15A [15]. These tests were performed in duplicate.

### 2.3. Dough rheological properties

Dough rheological properties were evaluated according to AACC method 54-21 [16]. Development time (DT), stability time (ST), and farinograph quality number (FQN) at 500 FU dough consistency were determined with a farinograph (Brabender GmbH & Co. KG, Duisburg, Germany) using 50 g flour samples. DT is defined as the time between the start of measurement (addition of water) and the point of the torque curve just before weakening begins, while ST is defined as the time between the first and second intersection points of the upper trace of the torque curve with the line of consistency, and FQN as the length from the water point to a point 30 FU below the center line of greatest consistency along the time axis [17]. FQN, which is strongly correlated with DT, can be easily and rapidly tested and has been accepted as a new index for rheological property measurement of dough with the farinograph [18].

### 2.4. Statistical analysis

Data analysis was performed by SPSS for Windows, version 13.0. Distributions of dough rheological properties and flour quality were tested by the Kolmogorov–Smirnov (K–S) normality test. The Kruskal–Wallis (K–W) test for non-parametric data was used to determine the significance of differences among mean values. Pearson's correlation analysis was used to assess the relationship among the six quality traits. Fisher's least significant difference (LSD) was calculated at significance levels of $P < 0.05$ and $P < 0.01$.

## 3. Results

### 3.1. General characteristics

As shown in Table 1, the mean values of DT, ST, and FQN were 2.7 min, 4.6 min, and 54.8 mm, respectively, and the mean values of PC, SV, and WGC were 13.2%, 30.3 mL, and 31.7%, respectively. As reflected by standard deviation (*SD*) and coefficient of variation (*CV*) values, there were wide variations in the six quality traits among the wheat cultivars. In terms of CV value, the highest was ST (58.1%), followed by FQN (42.4%), DT (40.5%), SV (15.3%), WGC (10.1%), and PC (9.1%). This order indicated that the CV values of dough rheological properties were larger than those of flour qualities.

### 3.2. Distributions of flour quality and dough rheological properties

As shown in Fig. 1, a normal distribution was found for PC, WGC, and SV of the wheat cultivars. However, DT, ST, and FQN were not normally distributed but showed marked left shifts. *Z*-statistics and significance levels based on the K–S normality test are listed in Table 2. The *Z*-statistics of PC, SV, and WGC were below the critical value ($Z_{0.05} = 1.63$), and their asymptomatic significance was larger than 0.05, indicating their normal distribution. However, the *Z*-statistics of DT, ST,