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Journal of Cereal Science 42 (2005) 261–266

Journal of
CEREAL
SCIENCE

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Application of solvent retention capacity tests for the prediction of mixing properties of wheat flour

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Received 2 March 2005; accepted 14 April 2005

Abstract

One hundred and ninety-two wheat genotypes including 150 released varieties and 42 germplasm lines were evaluated for solvent retention capacity (SRC) tests using 1 g of flour and 1 g of wholemeal to determine relationships with mixing properties of their doughs. Strong positive correlations ($p<0.001$) were observed between different SRCs (using both wholemeal as well as flour) and Farinograph water absorption (FWA). In multiple regression analysis, flour water SRC explained 41.2%, sodium carbonate SRC 24.6%, sucrose SRC 20.7% and protein content 13.5% of the total variability (multiple $r=0.91$) in FWA. The data demonstrated that water absorption is governed mainly to starch damage and pentosan content of the flour. Based on multiple regression analysis an equation was developed to predict FWA and a very high positive correlation ($r=0.91$) was observed between predicted FWA and actual FWA. LASRC exhibited significant positive correlations ($p<0.001$) with Farinograph and Mixograph parameters related to gluten strength such as the Farinograph peak time and mixing tolerance index and the mixograph peak time and peak dough resistance. Wholemeal flour SRCs accounted for 48% of the variation in FWA and was highly significant ($p<0.001$). The average values of FWA of corresponding clusters made using wholemeal and flour SRCs were not significantly different. This demonstrates that wholemeal SRCs together with grain protein content can be used to screen early generation lines for FWA. Since large numbers of diverse genotypes were used in the estimation of various parameters, high correlations observed between SRCs and functional properties including water absorption have obvious implications in breeding programs for the improvement of wheat cultivars.

Keywords: Solvent retention capacity; Farinograph; Mixograph; Gluten strength

1. Introduction

Solvent retention capacity (SRC) is the weight of solvent held by flour after centrifugation and expressed as the percentage of flour weight (14% mb). Slade and Levine (1994) developed solvent retention capacity tests that were adopted by AACC as method 56-11 (2000). In this test, four different solutions: lactic acid, sucrose, water and sodium carbonate are used to provide information on chemical and physical aspects of wheat samples. Generally, lactic acid SRC (LASRC) is associated with glutenin characteristics, sodium carbonate SRC (SODSRC) with starch damage, sucrose SRC (SUCSRC) with pentosan content and gliadin characteristics and water SRC (WSRC) with all four constituents (Guttieri et al., 2001). Thus, SRC profiling can provide information for identifying baking and processing characteristics of flours. Information generated during the last few years has indicated the usefulness of SRC in predicting the quality of soft wheat products (Guttieri et al., 2004; Ram and Singh, 2004). However, there are no reports on predicting the functional properties of the flour using SRCs.

The Mixograph and Farinograph are used to measure functional properties of flour including water absorption and to differentiate wheat flours of good and poor baking quality (Bekes et al., 2001; Finney and Shogren, 1972; Finney et al.,

Abbreviations AACC, American Association of Cereal Chemists; FMTI, Farinograph mixing tolerance index; FPT, Farinograph peak time; FS, Farinograph stability; FWA, Farinograph water absorption; GPC, grain protein content; LASRC, lactic acid retention capacity; MPDR, Mixograph peak dough resistance; MPT, Mixograph peak time; MS, Mixograph stability; SODSRC, sodium carbonate retention capacity; Solvent retention capacity, solvent retention capacity; SUCSRC, sucrose retention capacity; WSRC, water retention capacity.

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doi:10.1016/j.jcs.2005.04.005

1987; Gras and O'Brien, 1992; Ingelin and Lukow, 1999; Khatkar et al., 1996; Wikstrom and Bohlin, 1996). In the Farinograph, dough is developed by a pack-squeeze type of gentle kneading and shearing action and in the Mixograph by the folding and stretching action of mixing pins. During mixing, water is first brought into contact with flour particles that facilitates water absorption to develop the dough and a mixing curve is generated. The mixing curve contains a peak at which dough is fully developed and after that breakdown starts. Determination of optimum water needed to obtain a certain dough consistency is essential to give dough with optimal handling characteristics suitable for rheological testing as well as product quality (Stevens, 1987).

Because rheological tests such as Farinograph and Mixograph tests are time consuming, labour intensive and expensive, small-scale tests are required to predict the end-use quality of grain from early generation breeding material. Further, there is a major problem in finding optimum water absorption of flour for use in the Mixograph and Farinograph. The limited quantity of grain available from early generation segregating materials and the longer time required to mill thousands of samples are other constraints to the ease of analysis of breeding materials. The present investigation was conducted with the main objective to understand relationship between SRC tests and Farinograph and Mixograph parameters and to develop prediction equations for water absorption derived from flours from 192 wheat varieties released in India including 42 selected germplasm lines available at DWR, Karnal. Development of prediction models can be very valuable due to objective testing of flour quality, especially when the amount of sample is limited and the number of samples to be tested is excessive, as in early generation lines in wheat breeding programs. The SRC tests were conducted using 1 g of flour and 1 g of wholemeal to assess their interrelationships and utility in predicting functional properties of dough.

2. Experimental

2.1. Plant materials and methods

One hundred and fifty wheat varieties representing a wide range of cultivars and 42 germplasm lines were grown in replication at Karnal and evaluated by rheological and chemical tests. Two replicates of each sample were tempered (AACC method 26-10) and milled using a Brabender Senior Quadramat Mill (AACC method 26-21A) with a ∼70% extraction rate. Wholemeal was extracted using a Cyclotec mill (Cyclotec 1093, TECATOR, Sweden) Au supplier with a 0.5 mm sieve. Protein and moisture content were determined using NIR by AACC methods 44-16 and 46-30, respectively (AACC, 2000) of wheat grains at 14% mb. The SRC tests were conducted using 1 g wholemeal and 1 g flour in 15 ml tubes with conical bottoms. The material was dispersed in 5 ml solvent and kept for 20 min with intermittent agitation on a vortex mixer for 5, 10, 15 and 20 min followed by 15 min centrifugation at 1000*g* at room temperature. The solvent retention capacity was calculated as described by Guttieri et al. (2001). Mixograph analyses were conducted according to AACC method 54-40A with the modification that the Farinograph water absorption value was used as optimum water content. Mixographs were recorded electronically using a 10 g bowl (National Mfg Co., Lincoln, NE, USA) with the spring fixed at 8th position in the scale. Farinographs were produced according to AACC Method 54-21 using Brabender Farinograph fitted with 10 g bowl (Brabender, Duisburg, Germany) and operated at 30 °C. The constant flour weight procedure was used and absorption values were based on dough consistency at 500 BU.

2.2. Statistical analysis

Pearson's linear correlation coefficients among quality parameters were calculated by genotype means using the Package SPAR1, IASRI, New Delhi. The multiple regressions were conducted with the least square technique (LSQ) using Farninograph and Mixograph parameters as the dependent variable (Kendall, 1985). Independent variables were selected on the basis of their ability to optimise the R^2 value of the model. Cluster analysis was performed on the basis of Euclidean distances using nearest centroid sorting (Rao, 1952; SPAR1, IASRI, New Delhi), where the samples were allowed to segregate themselves arbitrarily into five clusters. The clusters were made using five independent variables; sodium carbonate SRC (SODSRC), sucrose SRC (SUCSRC), lactic acid SRC (LASRC), water SRC (WSRC) and grain protein content of both flour and wholemeal.

3. Results and discussion

3.1. Solvent retention capacity tests, Farinograph and Mixograph analysis

Large variations in solvent retention capacity values of flours were found among all genotypes studied. Sodium carbonate SRC varied from 63.9 to 87.2% (av. 77.5%), sucrose SRC from 75.1 to 97.9% (av. 85.8%), lactic acid SRC from 72.0 to 122.8% (av. 91.9%) and water SRC from 53.4 to 70.6% with the (av. 62.9%). Data clearly indicated the higher average values of sodium carbonate SRC and water SRC, while lactic acid SRC and sucrose SRC were in the mid-range. Generally, higher water absorption and medium strong gluten are preferred for making chapati. Chapati, an unleavened bread, is preferred and consumed in every household in India. This showed that selection pressure in breeding programme in India had been towards harder texture grains and medium strong gluten. The rheological and protein data also indicate the higher water absorption capacities and medium strong gluten of