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Relationships of flour solvent retention capacity, secondary structure and rheological properties with the cookie making characteristics of wheat cultivars

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ABSTRACT

The relationships of grain, flour solvent retention capacity (SRC) and dough rheological properties with the cookie making properties of wheat cultivars were evaluated. Cultivars with higher proportion of intermolecular-β-sheets + antiparallel β sheets and lower α-helix had greater gluten strength. The grain weight and diameter positively correlated with the proportion of fine particles and the cookie spread factor (SF) and negatively to the grain hardness (GH) and Na_2CO_3 SRC. The SF was higher in the flour with a higher amount of fine particle and with a lower Na_2CO_3 SRC and dough stability (DS). The breaking strength (BS) of cookies was positively correlated to lactic acid (LA) SRC, DS, peak time, sedimentation value (SV), G' and G''. Na_2CO_3 SRC and GH were strongly correlated. The gluten performance index showed a strong positive correlation with SV, DS, G' and G''. The water absorption had a significant positive correlation with sucrose SRC and LASRC. Cultivars with higher GH produced higher amount of coarse particles in flours that had higher Na_2CO_3 SRC and lower cookie SF.

1. Introduction

Indian wheat cultivars differ significantly in their composition and functionality compared to European and Western wheat cultivars because of differences in their genetic make, environmental conditions and duration of crop (Singh & Singh, 2010; Singh, Singh, & MacRitchie, 2011). Flours milled from Indian wheat cultivars had protein content ranging between 8.5% and 12.02% (Kaur et al., 2013). The majority of Indian wheat cultivars that are commercially grown have hard texture endosperm with grain hardness index ranging from 66 to 90, and have a medium protein content and weak gluten strength (Kaur et al., 2013). These wheat cultivars are best suitable for chapatti making, which is the staple food of Nothern Indians. In an earlier study, a detailed analysis of polymeric proteins in Indian wheat cultivars revealed a significant variation (Singh et al., 2011). In another study, we have reported the relationship between grain, flour, dough and the gluten properties (Kaur et al., 2013). Most of the wheat produced in India is consumed as chapatti followed by biscuits/cookies and other products.

The relationship between flour quality and dough rheology measured using farinograph, mixograph, extensograph, and alveograph and baked product (bread, cookies, and cakes) are widely used for the identification of varieties suitable for a particular product. The specific balance between gliadin and glutenin defines the quality of the flour and affects the viscosity and elasticity or strength of the dough (Khatkar, Bell, & Schofield, 1995). Empirical rheological measurements are commonly used for evaluating the gluten quality and baking functionality of flours (Singh & Singh, 2013). Farinograph and mixograph are used most often for evaluating the hard wheat for their suitability for bread making. Among dough rheology methods, the farinograph and mixograph are typically used to obtain information on a flour's water-absorption behaviour and gluten strength of flours (Shogren, 1990; Shuey, 1984). Dynamic oscillatory measurements involving small deformation is a fundamental approach and is being preferred for evaluating the wheat flour quality (Singh & Singh, 2013). The dynamic modulli measured by dynamic rheometer were correlated to the rheological properties measured by empirical methods such as the farinograph (Singh & Singh, 2013). The rheological properties of the dough are greatly influenced by water absorption, damaged starch, gluten elasticity and salt (Ren, Walker, & Faubion, 2008). Flours suitable for cookie making generally requires low water absorption, minimal gluten strength, and low damaged starch and arabinoxylans (Kweon, Slade, & Levine, 2011). Damaged starch generated during flour milling and

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arabinoxylans originating from the aleurone and bran layers of the wheat grain increase the water holding capacity of the flour, which is an undesirable characteristic for good quality cookie and cracker flours (Slade & Levine, 1994). The solvent retention capacity (SRC) test is used to predict the functional contribution of damaged starch, flour gluten and pentosans towards the quality of the finished-product (Kweon et al., 2011).

The cookie quality is associated with a soft wheat flour of low protein content (Morris & Rose, 1996). Soft wheat flour produces good quality cookies with a large spread factor, low thickness, and tender texture and with smaller particle size and low water absorption (Abboud, Rubenthaler, & Hoseney, 1985). Soft wheat yields less flour with a smaller average particle size and less damaged starch, which has a lower water retention capacity (Rogers et al., 1993; Parey & Delcour, 2008). Cookie dough made from hard wheat flour exhibits controlled elastic expansion (spreading), which expands to a maximum during baking and then contracts through a controlled elastic shrinkage (Slade & Levine, 1994). However, dough of soft wheat flour slowly expands to a maximum diameter and then dramatically collapses and results into good quality cookies. In India, soft wheat cultivars are not commercially grown, hence the flour milled from hard wheat cultivars is used for cookie making. In the present study we have evaluated the relationships of grain, flour and dough rheological properties with the cookie making properties amongst different Indian wheat cultivars.

2. Materials and methods

Wheat cultivars viz. HD2687, PBW175, HD2888, HD2985, C306, DBW14, HI1563, HD2643, DL788-2, HD2967, HD2987, PBW343, DBW17, CBW39, PBW590, HD2864, NI5439 and CBW38 from 2012 harvest were supplied by the Indian Agricultural Research Institute, Pusa Road, Delhi.

2.1. Physicochemical properties

The grains were conditioned and milled as described earlier (Kaur et al., 2013). The physico-chemical properties of flours from different cultivars were measured as described earlier (Kaur et al., 2013).

2.2. FTIR

The secondary structure of the dough samples were determined using FTIR spectroscopy. The dough was mixed in a Mixograph (National Mfg. Co. Lincoln, NE, USA) and the spectra were recorded on a Vertex 70 FTIR spectrometer (Bruker, Germany), equipped with an ATR (Attenuated Total Reflection) cell and a deuterated L-alanine doped triglycine sulphate (DLaTGS) detector. The spectra of empty cells were taken as background. The measurements were performed at wave numbers ranging from 800 to 2000 cm^{-1} (fingerprint region) with a 4 cm^{-1} resolution using the OPUS software. All spectra were the averages of 200 scans. The quantitative estimation of the secondary structure in dough was determined from the second-derivative spectra in the amide I region. Intermolecular β – sheets + antiparallel β sheets (1612–1632 cm^{-1}), α-helix (1650–1660 cm^{-1}) and β-turn + β-sheets (1665–1670 cm^{-1}) were calculated from the area of the peaks obtained at different wave numbers (Wang et al., 2014).

2.3. Solvent retention capacity (SRC)

The SRC tests were conducted according to the Approved Method 56-11 (AACC, International 2000). Four solvents, sodium carbonate (5%), sucrose (50%), lactic acid (5%) and distilled water were used for performing this test. Flour (5 g) was added in centrifuge tubes (50 ml) with screw cap. 25 ml of an appropriate solvent were added. The mixture was vortexed vigorously for 5 s to suspend the flour. The samples were vortexed for 20 min at one minute interval after every 5 min to allow the samples to solvate and swell. The centrifugation was done at 3000 rpm for 10 min. The supernatant was discarded and the wet pellet obtained was allowed to decant for 10 min and was weighed. The SRC was calculated as described earlier (Haynes, Bettge, & Slade, 2009).

2.4. Farinograph and mixograph characteristics

Dough mixing properties were analysed using 10 g (14% moisture basis) Farinograph (Brabender OHG, Germany) according to AACC method 54-21 (2000). Water absorption, dough development time (DDT) and dough stability (DS) were also determined.

Mixographs were recorded electronically using a 10 g bowl (National Mfg. Co. Lincoln, NE, USA) with the spring fixed at 10th position in the scale. For the construction of mixograms, the moisture content and protein content of the samples were determined according to the AACC method (2000). The midline curve parameters were only used for analysis because the midline parameters were reported to be very repeatable as compared to envelop curve parameters (Martinant et al., 1998). Various parameters evaluated including the mixograph peak time (MPT), mixograph peak height (MPH), mixograph peak width (MPW) and the weakening slope (WS).

2.5. Dynamic rheometry

The dynamic rheometry of dough was performed as described earlier in Kaur et al. (2013).

2.6. Cookie making

Cookies were prepared as per the AACC methods (2000). After baking, the cookies were allowed to cool for 30 min. The cookies were stacked upon a flat surface and the stack height was measured with a scale. The cookies were restacked and remeasured to get the average thickness in mm. The cookies were laid edge to edge and were measured for width. The cookies were rotated through 90° and re-measured for width in mm. The spread factor (SF) was obtained by finding the ratio between the average thickness and the width of the cookies. This gives an indication of their quality. The breaking strength (BS) of cookies was determined using a TA.XT-Plus texture Analyzer (Stable Microsystems, Crawley, UK). The three point break test was used to determine the texture of the cookies. The distance between the two beams was 52 mm. Another identical beam was attached to the load cell of 50 kg and was brought down at a speed of 2 mm/s till the cookies broke. The BS, i.e. peak force to break the cookies, was thus obtained.

2.7. Statistical analysis

Pearson correlation (r) and principal component analysis (PCA) were carried out for determining the relationship between the different variables using the Minitab Statistical Software (State College, PA). The PCA results were graphically represented by the projection of the first two principal components.