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A new lean no time test baking method with improved discriminating power

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A B S T R A C T

In response to customer concerns related to gluten strength in commercial baking, the Canadian Grain Commission assessed whether the Canadian Short Process (CSP) test bake method was generating useful data related to intrinsic strength of wheat varieties. Assessment of CSP loaf volume data for Canadian variety trials spanning 2003 to 2013 showed very little correlation with dough strength parameters as measured by farinograph and extensigraph. A lean no time (LNT) test baking method was developed that can better discriminate genotypes and provide objective indicators of the effect of intrinsic dough strength on baking quality. From early method development, through method validation and verification using diverse sets of samples targeting different Canadian wheat classes and grown in three different crop years, results showed the LNT method to be more discriminating and easily adopted by other laboratories. In 2015, the LNT method was adopted as the method of choice in future Canadian variety registration trials. The LNT method is fast, simple and well-suited to high throughput test baking conditions encountered in the evaluation of large numbers of breeder lines. A new objective parameter, loaf top ratio, was also introduced and found to correlate well with dough strength and dough handling properties.

1. Introduction

Test baking is often referred to as the ultimate test of wheat flour quality and has been used for decades to determine the inherent strength of wheat flour (Geddes and McCalla, 1934). Test baking has been part of the quality evaluation of Canadian wheat breeding trial entries for over 80 years. From the 1930's to the 1950's, a simple straight dough procedure with minimal ingredients and fixed-mixing time evolved to include potassium bromate, malt, ammonium phosphate and sugar (Kilborn et al., 1991). The Grain Research Laboratory (GRL) remix method was introduced in 1960 by Irvine and McMullan to assess the full potential of high protein bread wheat (Bushuk et al., 1969) and various modifications were made thereafter (Kilborn and Tipples, 1981). The remix-to-peak (RTP) method was used to assess high yielding spring, hard white spring, and red winter breeder lines from the mid-1990's to 2015. The RTP method involves two-stage mixing separated by long fermentation and is thus a labor intensive and low throughput method not well suited for large volume testing. The other predominant bake method used for the annual evaluation of Canadian bread wheat trials from 1981 to 2015, was the Canadian Short Process (CSP) bake method (Preston et al., 1982). This method was originally developed to assess flour quality for the domestic baking industry where doughs were increasingly being fully developed by a combination of mixing and high levels of ascorbic acid (no-time) rather than bulk fermentation (Preston et al., 1997).

Loaf volume (LV) is considered an important and objective parameter of baking quality of flour because dough expansion and resistance to collapse depend in part on the rheological properties of optimally developed dough (Gandikota and MacRitchie, 2005). However, assessment of CSP loaf volume data for Canadian variety trials spanning 2003 to 2013 showed very little correlation with dough strength parameters as measured by farinograph and extensigraph (Dupuis and Fu, 2014). Results for the ten years 2003–2012 showed that variation in LV (for CSP and RTP bake methods) had little to do with dough strength as measured by

Abbreviations: CNHR, Canada Northern Hard Red; CPSR, Canada Prairie Spring Red; CSP, Canadian Short Process; CWHWS, Canada Western Hard White Spring; CWRS, Canada Western Red Spring; CWRW, Canada Western Red Winter; DDT, dough development time; GRL, Grain Research Laboratory; LNT, lean no time; LTR, loaf top ratio; LV, loaf volume; R_{max}, maximum resistance to extension; RTP, remix-to-peak.

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farinograph dough development time (r^2 0.09 to 0.12) or stability (r^2 0.10 to 0.17) (Dupuis and Fu, 2014). The extensigraph, eliminated from Canadian variety registration trials in the late 1990's, was reinstated in 2013 due to its ability to assess dough strength more effectively than the farinograph (Suchy et al., 2016). But results from registration trials in 2013 (Dupuis and Fu, 2014) indicated the same low correlation between LV and dough strength as measured by the extensigraph maximum resistance to extension, R_{max}, (r^2 0.02 to 0.10) or energy (r^2 0.09 to 0.14). Thus LV obtained by the test baking methods at the time was a poor indicator of the effect of dough strength on baking quality.

Others have similarly reported weak relationships of certain quality parameters to baking performance. MacRitchie (2014) suggests a dough expansion test that saves time, is highly correlated with the baking test, and takes into account the impact of protein and lipids on baking quality. Thanhaeuser et al. (2014) suggest that the choice of a baking test is critical to any studies of baking performance. Graybosch et al. (1999) reported that LV obtained by small-scale (100 g) test baking explained less than 50% of the variation in commercial-scale test baking. Although LV is influenced by flour components other than protein, as well as baking formulation, baking process, and baker, an effective test baking method should be able to discriminate genotypes with diverse dough strength. This has been the goal of test baking for decades (Geddes and McCalla, 1934) and part of the motivation behind the attempt to standardize test baking for as many decades (Aitken, 1934).

Canada Western Red Spring (CWRS) is a marketing class of premium wheat for bread making and new varieties emerge annually from three large Canadian bread wheat trials. In recent years, there have been customer concerns related to gluten strength in commercial baking. In response, the Canadian Grain Commission took several measures to address these concerns. Firstly, currently registered varieties eligible for the premium CWRS class but exhibiting lower than acceptable strength were identified and re-classified. Secondly, the extensigraph was re-incorporated into the quality evaluation of wheat breeder trials in 2014. This decision was based on the observation that the farinograph was insufficient for discriminating inherent strength in different wheat lines. A third strategy was to develop a test bake method that could replace the CSP test bake method and provide useful data related to intrinsic strength of wheat varieties. Given the wide range of commercial formulations and processing conditions employed by the baking industry, a test bake method focused on assessing intrinsic flour quality of future cultivars rather than on any one specific commercial condition would provide more valuable supplementary data to wheat registration trials.

The main objectives of this study were to investigate whether modifications to the CSP method could (i) improve loaf volume as a predictor of the effect of dough strength on baking quality, (ii) improve the discriminating power for assessing advanced breeder lines, and (iii) provide a higher throughput method for test baking of large numbers of samples with limited size. This modified method is referred to as the lean no time (LNT) method. If these objectives could be met, the LNT method would be a suitable replacement to the CSP as well as the RTP test methods. Another objective of this study was to evaluate the usefulness of a new parameter, loaf top ratio, as an objective measure of dough handling properties.

2. Experimental

2.1. Chemicals

All chemicals were of analytical grade and purchased from Fisher Scientific, USA. Baking ingredients (sugar, salt, shortening and fresh yeast) were retail or commercial grade and purchased from BakeMark Canada (Winnipeg, MB) or Pratts Wholesale Ltd. (Winnipeg, MB).

2.2. Wheat milling, analytical and rheological tests

Wheat was milled on a Buhler test mill (Canadian Grain Commission, Winnipeg, MB) at a constant extraction rate of 74%. Protein content (N (nitrogen) x 5.7) was determined by combustion nitrogen analysis. Protein content was calculated from total nitrogen as determined using a LECO Truspec N CNA analyzer calibrated with EDTA or an Elementar rapid N cube calibrated with L-aspartic acid and reported on a constant moisture basis. Moisture content was determined by AACC method 44–15.02, following the procedure for one-stage air-oven.

The farinograph test was conducted using AACC Method 54–21.02, following the procedure for constant flour weight using the 50 g bowl. Dough properties of the method development sample set were characterized by the standard extensigraph test (AACC Method 54–10.01). A modified extensigraph test (Suchy et al., 2016), based on AACC Method 54–10.01 but using a pin-mixer for dough preparation and resting 90 min, was conducted on all flour samples from 2013 and later. Rheological properties were described by farinograph dough development time (DDT, min), stability (min), and extensigraph area (cm^2), maximum resistance to extension (R_{max}, BU), and extensibility (cm).

2.3. Test baking methods

The CSP baking test, as described by Preston et al. (1982) was followed, using (on a % flour basis) 3.0% fresh yeast, 150 ppm ascorbic acid as the oxidant, 2% salt, 4% sugar, 3% shortening, 0.1% ammonium phosphate, 4% whey powder and 0.08% malt. Bake absorption was typically around farinograph absorption plus 4%, but was optimized based on subjective assessment of dough feel at panning. Dough was mixed to peak development in a Swanson type 100–200 g pin mixer (National Manufacturing Co., Lincoln NE) at 116 rpm, allowed to rest 15 min in covered crocks in a resting cabinet held at 30 °C, punched by hand 7 times, and then allowed to rest another 15 min. Dough was passed through sheeting rolls at incrementally smaller gap settings of 8.7, 5.6 and 4.0 mm (11/32, 7/32 and 5/32 inch) and subsequently molded and panned. A control flour dough was proofed in a proofing cabinet (38 °C, 85% RH) to 120 mm and the proof time (about 65 min) to reach this panned dough height was subsequently used for all samples. Loaves were baked for 30 min at 205 °C (400 °F).

The RTP baking test is a modification of the remix baking test of Irvine and McMullan (1960), as described in detail by Kilborn and Tipples (1981). Dough was mixed for 3.5 min in a Swanson type 100–200 g pin mixer (National Manufacturing Co., Lincoln NE) at 90 rpm. Fermentation (165 min, 30 °C, 83% RH) was followed by a second mixing stage, mixing to peak consistency. After a second fermentation (25 min), dough was sheeted as described in the CSP method, molded, panned and proofed (55 min). Loaves were baked for 30 min at 218 °C (425 °F). For both the CSP and RTP methods, loaves were produced from 200 g of flour (14% m.b.) in baking pans designed and manufactured in-house (outer dimensions, top: 17.9 cm long, 12.4 cm wide; bottom: 14.2 cm long, 9.1 cm wide; 7.3 cm deep; approximate volume 1120 mL) and having an approximate pan volume-to-dough weight ratio of 3.4 cm^3/g.

The LNT test baking method was developed by modifying the previously described CSP test baking method. Compared to the CSP method, the LNT method used higher bake absorption (farinograph absorption plus 6–7%, but was optimized based on subjective