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Quality characteristics of northern-style Chinese steamed bread prepared from soft red winter wheat flours with waxy wheat flour substitution

Fengyun Ma [a, b], Taehyun Ji [a], Byung-Kee Baik [a, *]

[a] United States Department of Agriculture (USDA), Agricultural Research Service (ARS)-CSWQRU, Soft Wheat Quality Laboratory, 1680 Madison Avenue, Wooster, OH, 44691, USA

[b] Department of Horticulture and Crop Science, The Ohio State University, 1680 Madison Avenue, Wooster, OH, 44691, USA

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ABSTRACT

Quality characteristics of northern-style Chinese steamed bread (CSB) prepared from two soft red winter (SRW) wheat flours blended with 0–30% waxy wheat flour (WWF) were analyzed to estimate the influence of starch amylose content. The increased proportion of WWF in blends raised mixograph absorption with insignificant changes in protein content and dough strength-related parameters. WWF incorporation generally increased specific volume and crumb softness of CSB. The analysis of covariance revealed that CSB quality attributes were little affected by protein content and dough strength-related parameters, indicating that starch amylose content was largely responsible for the changes in CSB quality. Flour blends with 5–10% WWF, of which starch amylose content was 22.4–24.7%, produced CSB with superior crumb structure compared to other blends, but insignificant changes in surface smoothness, stress relaxation and total score compared to the respective control wheat flours. Flour blends with 15% WWF to produce a starch amylose content of 21.4–22.7% exhibited reduced staling of CSB with total scores comparable to the respective control wheat flours. CSB prepared from blends with more than 10% WWF exhibited a higher soluble starch content, indicative of reduced starch retrogradation, than that prepared from wheat flours without WWF during storage for 3 days.

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1. Introduction

Chinese steamed bread (CSB), a staple of wheat-based traditional fermented Chinese food, has been consumed for almost two millennia in China. The basic ingredients for making CSB are wheat flour, water and yeast or sourdough. The shelf-life of CSB is only 1–3 days when stored at room temperature, and becomes shorter at a higher storage temperature or a reduced storage relative humidity (Qin et al., 2007). CSB shelf-life extension faces a great challenge as it is quick staling. CSB staling, also referred as hardening, is commonly defined as the loss of freshness (mouth-feel, flavor and moisture loss) during storage, lowering eating quality and marketability. Increased crumb firmness over time is a common indicator of CSB staling and a most important characteristic noted by consumers.

Wheat varieties are classified as waxy, partial waxy, normal or high-amylose wheat based on starch amylose content (Graybosch, 1998; Nakumura et al., 1995). As it is lacking in amylose molecules, waxy wheat starch has a lower pasting temperature and a lower setback value, absorbs more water, and exhibits less syneresis as compared to normal wheat starches (Baik and Lee, 2003; Sasaki et al., 2000). Waxy wheat is known to be more resistant to retrogradation during storage than wheat of normal starch endosperm, and could be used to retard the staling of wheat products (Sasaki et al., 2000).

A number of studies have been conducted to understand the potential of waxy wheat flour (WWF), including as a source for blending flour to improve shelf-life stability and the processing quality of wheat products (Baik and Lee, 2003; Bhattacharya et al., 2002; Guo et al., 2003; Lee et al., 2001; Morita et al., 2002; Yi et al., 2009). The uses of WWF have been tested in several products including bread (Bhattacharya et al., 2002; Morita et al., 2002) and noodles (Baik and Lee, 2003; Guo et al., 2003). WWFs produced bread with softer crumb texture, even after storage, than wheat

* Corresponding author.
E-mail address: byungkee.baik@ars.usda.gov (B.-K. Baik).

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flours of normal type starch (Morita et al., 2002). However, bread baked from WWFs exhibited a highly porous crumb structure and a gummy texture, and tended to collapse during storage (Garimella Purna et al., 2011; Morita et al., 2002; Jonnala et al., 2010). Noodles made from WWFs were sticky and soft, and failed to maintain the integral structure of the noodle strands (Baik and Lee, 2003). Since 100% WWF is not suitable for making bread or noodles, attempts have been made to use blends of waxy wheat and normal wheat flours for the production of bread and noodles with improved quality. Previous studies on the effects of WWF addition on bread staling have been in disagreement. Bhattacharya et al. (2002), Hayakawa et al. (2004) and Morita et al. (2002) observed a reduction in the crumb firmness of bread with the addition of WWF even after storage. In contrast, Graybosch (2001) found an increase in crumb firmness of bread made from flour blends containing WWF during storage. In a separate study, the incorporation of WWF resulted in softer bread immediately after baking, but didn't retard staling during storage (Garimella Purna et al., 2011). The inconsistent effects of WWF substitution on crumb firmness during storage may be due to the differences in baking formulations and processes, storage conditions and characteristics of bread baked from waxy wheat and normal wheat flour blends.

Up until now, information about the shelf-life extension of CSB with incorporated WWF is still very limited. Qin et al. (2007) reported that the quality of northern-style CSB cannot be improved by the addition of WWF, but the firmness of fresh and re-steamed CSB decreased with an increasing content of WWF at proportions up to 25% when compared to the control wheat flour, without elaborating much on the staling of CSB during storage and the associated changes in crumb characteristics.

The objectives of this study were to identify the effects of starch amylose content on the quality and staling of northern-style CSB using flour blends of waxy wheat and normal wheat flours and to determine the optimal proportion of WWF for the production of CSB with improved quality.

2. Materials and methods

2.1. Materials

A SRW waxy wheat breeding line, NX10MD2268 Waxy 1711 (Waxy 1711) procured from the USDA-ARS, Lincoln, NE, and two SRW wheat varieties, Kristy and OH04-264-58, with normal starch endosperm, were selected to produce flour blends of varying starch amylose content with 0, 5, 10, 15, 25 and 30% WWF. Kristy and OH04-264-58 were similar in protein content and dough strength.

Wheat grain was tempered to 15% moisture prior to milling for 12 h, and was milled to obtain flour of about 70% extraction using a Miag Multomat Mill (Buhler, Inc., Braunschweig, Germany).

2.2. Proximate analysis and rheological properties of flours

Flour moisture, ash content and protein content were determined according to AACC Approved Methods 44–16.01, 08–01.01 and 46–30.01, respectively (AACC International, 2010). The determination of total starch content was performed according to AACC Approved Method 76–13.01 (AACC International, 2010) using a Megazyme Total Starch Assay Kit (Megazyme International Ltd., Wicklow, Ireland). The amylose content of flour was measured according to the procedure described by the manufacturer for the Megazyme Amylose/Amylopectin Assay Kit (Megazyme International Ltd., Wicklow, Ireland). Flour color was determined using a Hunter Lab Mini Scan XE plus colorimeter, Model 4500L (Hunter Associates Laboratory, Inc., Reston, VA, USA), and expressed with L^* (100 for perfect whiteness/zero for blackness), a^* (+redness/-greenness), and b^* (+yellowness/-blueness).

Dough mixing properties were measured using a 10 g Mixograph (National Manufacturing Co., Lincoln NE, USA) following AACC Approved Method 54–40.02 (AACC International, 2010). Dough mixograph absorption was initially calculated based on flour protein content using AACC Approved Method 54–40.02, but was finally optimized for each sample based on a series of mixograms. The parameters recorded were midline peak time (MPT, min) and midline peak value (MPV, %Torque), and were obtained from the mixogram and collected using MixSmart Software Version 3.8 (National Manufacturing Co., Lincoln, NE, USA). Wet and dry gluten contents of flour were determined using a Perten 2200 Glutomatic System (Perten Instruments AB, Huddinge, Sweden) according to AACC Approved Method 38–12.02 (AACC International, 2010). The sodium dodecyl sulfate sedimentation (SDSS) test was performed according to the method described by Axford et al. (1979) with minor modifications in flour weight to 3 g (14% moisture basis) and a sedimentation time of 20 min.

2.3. Pasting profile determination

Flour pasting properties were measured using a Rapid Viscosity Analyzer (RVA) following AACC Approved Method 76–21.01 (AACC International, 2010) with minor modifications. Flour (3.5 g, 14% moisture basis) was weighted in a canister, to which 25 mL water containing 1 mM $AgNO_3$ was added in order to eliminate α-amylase activity that could mask the actual pasting behavior of the flour samples (Crosbie et al., 1999). Parameters including peak viscosity (Rapid Viscosity Analyzer Unit, RVU), breakdown value (RVU), final viscosity (RVU), setback value (RVU) and pasting temperature (°C) were recorded.

2.4. Preparation and quality evaluation of Chinese steamed bread

Northern-style CSB was prepared from flour blends according to the method described by Ma and Baik (2016). The CSB formulation included flour (100 g, 14% moisture basis), instant yeast (1.5 g), and water (78% of mixograph absorption). Mixing times were calculated based on MPT according to the method described by Ma and Baik (2016). Flour, water and yeast were mixed to achieve optimal dough and gluten development using a 100 g mixer (National Manufacturing Co., Lincoln, NE, USA). After fermentation for 1 h at 32 °C and 85% relative humidity, dough was mixed again using a 100 g mixer, sheeted 20 times through a pair of rolls with a 7 mm gap, and then rounded to a dome shape 5.5 cm in height. Dough was proofed for 15 min at 32 °C and 85% relative humidity, and steamed for 20 min in a commercial steamer (Southbend, NC, USA). After cooling for 15 min at 24 °C, the quality attributes of CSB were evaluated following the method described by Ma and Baik (2016). CSB total score (100) includes 20 for specific volume (vol/wt), 5 for spread ratio (width/height), 10 for surface smoothness, 15 for crumb structure, 5 for external color, 5 for crumb color, 5 for brightness and 35 for stress relaxation. Stress relaxation (SR) was calculated from the two compression forces (P1 and P2) by a texture analyzer (TA.XT2i, Stable Micro Systems, Haslemere, Surrey, UK) as described by Huang et al. (1995) using the equation $SR = (P1-P2)/P1 \times 100$.

2.5. Moisture content, firmness, soluble starch content and thermal properties of Chinese steamed bread

After cooling at 24 °C for 1 h, CSB was kept in an airtight plastic Ziploc bag until analysis at 24 °C. The moisture content, firmness, soluble starch content and thermal properties of CSB

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