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Characteristics of remixed fermentation dough and its influence on the quality of steamed bread

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ABSTRACT

In this study, the effects of the amount of remixed flour on the properties of remixed fermentation dough and the quality of Chinese steamed breads were investigated. The hardness, chewiness and whiteness of steamed bread increased when the amount of remixed flour was higher than 10 g/100 g, whereas the specific volume of steamed bread significantly decreased. SEM analysis demonstrated that the gas cells of the steamed bread remained as a discrete spherical or oval-like entity only at 10 g/100 g level of remixed flour. Time-domain NMR showed that water migrated from T_{22} population to T_{21} population with increasing the amount of remixed flour. The XRD results indicated that starch in the steamed bread with remixed flour was gelatinized. A significant decrease of both the rate and extent of starch hydrolysis of the steamed bread was observed when flour was remixed.

1. Introduction

Chinese steamed bread is the most popular traditional fermented wheat food in China, representing approximately 40% of wheat consumption in China (Kim, Huang, Zhu, & Rayas-Duarte, 2009). Two types of steamed bread, northern and southern styles, are generally recognized based on the production process, the composition of ingredients and consumption regions (Zhu, 2014). Most research focuses on northern style steamed bread, since it is an important staple food in the wheat-growing area of northern China. The northern style steamed bread has a higher arch domed shape, dense structure and a very chewy eating quality (Zhu, 2014). The traditional procedure for northern style steamed bread making includes mixing of the dough, full fermentation, neutralization, remixing and molding, proofing, and steaming. Remixing is the critical and unique stage for making northern style steamed bread (socalled Qiang Mian mantou). After the dough is fully fermented, more flour is mixed in at a ratio of additional flour up to 40% by weight, which is called remixed fermentation dough. Much of the steamed bread in rural China is still produced this way. Sometimes the remixing step is also used in industry in recent years.

The quality of steamed bread can be affected by many factors. Since the 1990s, considerable studies have explored the influence of various wheat varieties and ingredients on steamed bread quality (Huang, Yun, Quail, & Moss, 1996; Kim et al., 2009; Lin, Liu, Bi, & Li, 2012; Sun, Zhou, Zhi, & Li, 2007). In recent years, the development of traditional biotechnology for improving steamed bread quality has become an attractive subject. However, most of these studies focus on the technological role of traditional and novel starters in dough fermentation (Li, Li, Deng, & Liu, 2014; Wu et al., 2012; Yeh, Wu, Charles, & Huang, 2009). The effects of the traditional processing procedure on the properties of wheat dough and Chinese steamed bread are little known. The remixed fermentation dough gives the unique quality of the northern style steamed bread, and its technological role need to be elucidated. It has been reported that there is a significant influence of the dough hydration level on the bread quality (de la Hera, Rosell, & Gomez, 2014). When remixed fermentation dough is used, the remixed flour can significantly affect the water distribution and the micro-structure of dough. Therefore, understanding the effects of remixed flour on the properties of dough system and the end-product quality is essential for guiding the production of the wheat products.

In light of the unique properties of the remixed fermentation dough in making the traditional northern style steamed bread, the effects of amount of remixed flour on the dough characteristics and quality of Chinese steamed breads were investigated.

2. Materials and methods

2.1. Materials

Wheat flour with 10.1 g/100 g protein, 0.35 g/100 g ash, 0.75 g/100 g fat and 14.2 g/100 g moisture was used for this

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study, which was supplied by Jinyuan Flour Co., Ltd. (Zhengzhou, China).

2.2. Steamed bread making process

The steamed bread was made by three steps. Firstly, full fermentation dough is prepared with 500 g wheat flour, 225 g water and 4 g yeast. The ingredients were mixed in a mixing machine (SZM5, Xuzhong Co. Ltd., Guangzhou, China) for 15 min. Then, the dough was fermented at 30 °C and 85% relative humidity. Secondly, after the fermentation, 0 g, 50 g, 100 g and 150 g (0 g/100 g, 10 g/100 g, 20 g/100 g and 30 g/100 g wheat flour on the basis of the wheat flour used in the first step) wheat flour were remixed with the full fermentation dough for 15 min, then the dough was sheeted 20 times on the surface pressure machine (JCXZ, Dongfu Jiuheng Instrument Technology Co. Ltd., Beijing, China) and split into 100 g portions. The chunks were formed into round shape by hand and fermented at 30 °C and 85% relative humidity for 35 min in a controlled fermentation cabinet (JXFD 7, Dongfu Jiuheng Instrument Technology Co. Ltd., Beijing, China). Thirdly, the proofed doughs were steamed for 25 min in a pot using a steam tray and boiling water (JYC-21HEC0, Joyong, Jinan, China). After cooling at room temperature for 1 h, the quality of steamed bread was evaluated.

2.3. Steamed bread evaluation

Steamed bread was sliced transversely to obtain uniform slices of 15 mm thickness. Two slices taken from the center were evaluated. Hardness and chewiness of the crumb was performed using a Texture Analyzer (TA.XT2i, Stable Micro Systems, Ltd., Godalming, UK) equipped with a 35 mm diameter aluminum cylindrical probe with pre-test speed 1 mm/s, test speed 5 mm/s, post-test speed 5 mm/s and trigger force 5 g. The deformation level was 75% of the sample height. Steamed bread specific volume was measured using the rape seed displacement method and the whiteness was determined by whiteness meter (WGB-IV, TASAN Co. Ltd., Hangzhou, China) (Li, Li, Deng, Bian, & Liu, 2014; Sim, Noor Aziah, & Cheng, 2011).

2.4. Scanning electron microscopy (SEM)

The remixed dough and steamed bread samples were prepared for SEM examination by the methods reported previously (Kim, Morita, Lee, & Moon, 2003). In brief, the samples were freeze dried, and then fractured into sizes of about $1 \times 1 \times 0.5$ cm using a knife. The morphology of the samples was evaluated by the SEM (Quanta 200, FEI, Hillsboro, USA) operating at an accelerating voltage of 15 kV.

2.5. Nuclear magnetic resonance (NMR) analysis

Spin–spin relaxation time (T_2) was determined using the NMR system to observe the water migration in dough system. The relaxation time measurements were performed on a Niumag Desktop Pulsed NMR Analyzer (MicroMR-CL-I, Shanghai Niumag Electronics Technology Co. Ltd., Shanghai, China). Transverse relaxation (T_2) was measured using the Carr–Purcell–Meiboom–Gill (CPMG) pulse sequence. The parameters of the NMR test are as follows: the number of points selected to measure on every sample was 163,238, the number of echos was 2000, the number of scans was 4, and the relaxation time decayed was 1 s. The CPMG data were fitted using T_2-fit program (Ningbo Jianxin Machinery Co., Ltd., Ningbo, Zhejiang, China).

2.6. In vitro digestion of starch in steamed bread

To evaluate the digestibility of steamed bread, an *in vitro* starch digestion model simulating gastric and small intestinal conditions was used and modified (Bordoloi, Singh, & Kaur, 2012). In brief, 10 g of steamed bread were added to a jacketed glass reactor and digested in 100 ml simulated gastric fluid (SGF, containing 0.4 g pepsin, pH 1.2). The reactor jacket was maintained at 37 ± 1 °C in water bath. After 30 min, pepsin was inactivated by changing the pH to 6.8 using 1 M NaOH. Then 14 ml simulated intestinal fluid (SIF) (containing 1 g pancreatin, amyloglucosidase and invertase, respectively) was added to the reaction mixture to simulate digestion in the small intestine for 120 min. Aliquots were withdrawn at 1, 5, 10, 20, 30, 45, 60, 90, 120 min of digestion during the small intestinal phase and then immediately analyzed for reducing sugars. The reducing sugar was analyzed by the 3,5-dinitrosalicylic acid method using a maltose standard curve (Miller, 1959).

2.7. X-ray diffraction (XRD) analysis

Wide angle X-ray scattering patterns of remixed dough and steamed bread samples (vacuum freeze drying and milled to 100 mesh powder) was performed on Bruker D8-Advance XRD instrument (D8 Advance, Bruker AXS Inc., Germany). The diffractograms were collected under the conditions of 40 kV, 35 mA, with the scanning angle (2θ) from 4° to 40° at a scanning rate of 4°/min.

2.8. Statistical analysis

The results reported in this article are the average values ± S.D. and the significant differences between two samples were analyzed by the Duncan's multiple-range test ($P < 0.05$) using SPSS software (SPSS 19.0, SPSS Inc., Chicago, U.S.A.).

3. Results and discussion

3.1. Effects of the amount of remixed flour on the steamed bread quality

The effects of the amount of remixed flour on the quality of steamed bread are shown in Table 1. It was demonstrated that the higher amount of remixed flour (>10 g/100 g) could significantly increase the hardness and chewiness of steamed bread. This proved the chewy eating quality of the northern style steamed bread. It should be noted that as no additional water was added in the remixed flour procedure, the relative water content decreased when the full fermented dough remixed with higher amount of flour, which could be the reason for the unique quality of northern style steamed bread. It was reported that an increase of the hardness was observed when decreasing the water content in the recipe of making bread (de la Hera et al., 2014).

The specific volume of steamed bread significantly decreased as the amount of remixed flour higher than 10 g/100 g. The lower specific volume resulting in denser crumb and more compact gas cells (de la Hera et al., 2014; Li, Li, Deng, Liu, 2014). Thus, the decreased specific volume of steamed bread maybe related to the poor leavening and disrupted gluten network structure due to the unavailability of enough water in the dough. The steamed bread prepared by the remixed fermentation dough showed higher whiteness. The improved whiteness of the steamed bread may be due to the changed interior microstructure and composition (Li, Li, Deng, Bian, et al., 2014). Based on the data shown in Table 1, it seems that the remixed fermentation dough would be appropriate for the improved chewiness and whiteness. Consumers in northern of