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Effects of superfine grinding of bran on the properties of dough and qualities of steamed bread

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ABSTRACT

In order to investigate the influence of superfine grinding of wheat bran on the qualities of southern and northern-styles steamed bread, wheat bran with different particle size (coarse, medium and superfine grinding) was blended with low/medium protein content flours. For the two kinds of wheat flours, their water absorption, peak viscosity, starch hot-gel stability and starch crystallinity significantly ($P < 0.05$) increased with the reduction of bran particle size investigated by Mixolab, while dough development time decreased. The results of Rheofermentometer F4 showed that superfine grinding of bran resulted in lower maximum height and total CO_2 production of dough during fermentation compared to coarse and medium wheat bran. The Chinese southern and northern-styles steamed bread making test showed that reducing the bran particle size could significantly ($P < 0.05$) decrease the specific volume of steamed bread. Higher crumb hardness and starch relative crystallinity after 24 h storage were observed in steamed bread of superfine bran than those of coarse or medium wheat bran. These results demonstrated that the superfine grinding of wheat bran (from ~433 μm to ~39 μm) could have detrimental effect on the quality of steamed bread.

1. Introduction

Wheat bran is a main by-product from the conventional milling industries. Due to its high content of dietary fibers, good quality proteins (albumin and globulins), minerals (e.g. Ca, Fe, Zn) and antioxidants (phenolic acids, flavonoids and carotenoids), consumption of wheat bran can do many benefits to human health, such as hypertension, diabetes, and colon cancer (Chen et al., 2011). However, incorporation of wheat bran in foods can reduce their structure and sensory quality, and cause less consumer acceptance. Consequently, the production of bran enriched foods is still a challenge, in particular when maintaining their functional and quality properties. Among the characteristics of wheat bran which affect the qualities of whole-wheat products, studies have established that particle size of the bran has a remarkable influence on the dough properties and quality of finished products. However, the findings of those studies are often contradictory. Some studies showed that reducing the bran particle size had a beneficial effect on foods, such as Asian noodle, snack cracker and flat bread (Chen et al., 2011; Niu et al., 2014; Wang et al., 2016) while other researchers found that smaller bran particle size had a detrimental effect on bread quality (Noort et al., 2010; Cai et al., 2014). Products that do not require gluten development may have different particle size requirements comparing to those that do (Doblado-Maldonado et al., 2012). In addition, wheat bran is not a standardized product with a defined quality and chemical composition. The composition of commercial bran depends upon many factors, including wheat class, grain shape and size, thickness of bran layers, milling system and type of flour produced (Zhang and Moore, 1997).

Chinese steamed bread is the most popular traditional fermented wheat food in China, representing approximately 40% of wheat consumption in China. It is also widely consumed in other Asian countries (such as Japan, South Korea, Philippines, Thailand, etc.) accounting for 5–15% of total wheat consumption. There are two major types of steamed bread made in China. The northern-style steamed bread has a very cohesive, elastic and dense texture. Whereas, the southern-style steamed bread is commonly known for a more open crumb structure, softer texture and a white surface. Flour with 10.0–12.0% protein is desirable for the

Abbreviations: LPF, low protein content flour; MPF, medium protein content flour.

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production of northern-style steamed bread, while flour with 9.5–11.0% protein is favored for making southern-style steamed bread (Crosbie et al., 1998).

The influence of wheat bran particle size on the steamed bread-making quality is still not clearly understood. In this study, wheat bran of different particle sizes was prepared by medium or superfine grinding and blended with low/medium protein content wheat flour. The dough rheological properties, loaf volume of bread, bread crumb texture and starch retrogradation were studied. Our objective was to investigate the superfine grinding of bran on the steamed bread-making quality and if there is difference of the bran particle size effect between northern and southern-styles steamed bread.

2. Materials and methods

2.1. Materials

Commercial wheat bran was provided by Fu Ruixiang food company (Bozhou, Anhui, China). The low and medium protein content flour, which protein contents were 9.92% and 11.52% (14 g/100 g moisture basis) respectively, were obtained from Fengzheng Milling Company (Shandong, China). The low protein content flour (LPF) was used to prepare southern-style steamed bread and the medium protein content flour (MPF) was used to prepare northern-style steamed bread. The instant dry yeast was obtained from Angle Company (Hubei, China). All chemicals, solvents and reagents used in this study were at least of analytical grade.

2.2. Preparation of bran of different particle size and determination of their particle size distribution

In this study, whole wheat bran without any grinding was used as coarse bran. To prepare wheat bran of smaller particle sizes, whole wheat bran was ground by a hammer mill (30 B, Teng Shuoge Instruments Co., Ltd, Changzhou, China) as medium-ground bran. Whole wheat bran was ground by a superfine grinder (KC-701, Kaichuang Instruments Co., Ltd, Beijing, China) as superfine-ground bran. The particle size distribution and median particle diameter of wheat flours and wheat bran were determined using Malvern Laser Light Scattering (Mastersizer 3000, Malvern Instruments Co., Ltd, England). Wheat bran 1–2 g was dispersed in alcohol, using with a size range of 0.02–2000 μm. The results were expressed as D (0.1), D (0.5) and D (0.9), corresponding to the maximum diameters of 10%, 50%, and 90% of the particles, respectively (in % of total volume).

2.3. Flour blends preparation and damaged starch determination

Wheat bran samples of different particle size (coarse, medium-ground and superfine-ground) were blended with low/medium protein content flour at weight ratio of 8:2 (on 14% moisture basis), respectively. The damaged starch content of wheat flours and flours with wheat bran was determined according to the AACC International Approved Methods (76–30.02).

2.4. Determination of dough mixing and pasting characteristics by Mixolab

Mixing and starch pasting characteristics of dough were determined using Mixolab analyzer (Chopin Technologies, Villeneuve-La-Garenne, France) according to AACC International Approved Method 54–60.0. The parameters obtained from Mixolab included the percent of water required for the dough to produce a torque of 1.1 ± 0.05 Nm (water absorption, %), the time to reach maximum torque at 30 °C [C1 time (dough development time), min], the elapsed time that the torque was kept at 1.1 Nm (stability, min), starch gelatinization (C3, Nm), stability of the hot formed gel (C3-C4, Nm), and starch retrogradation (C5, Nm) during the cooling phase.

2.5. Determination of dough fermentation characteristics by rheofermentometer

Rheofermentometer F4 (Chopin Technologies, Villeneuve-La-Garenne, France) was used to analyze dough fermentation characteristics. The doughs were prepared according to manipulative instructor of Rheofermentometer F4 using a Alveograph instrument (Chopin Technologies, Villeneuve-La-Garenne, France). A piece of dough 315 g was placed in the rheofermentometer basket and a piston with 2 kg resistance weight was placed on top of it. All rheological measurements were maintained at 28.5 °C and the duration of the test was 3 h. The fermentation rheological parameters contained: Hm (mm), the maximum height at development time; h (mm), dough height at the termination; (Hm−h)/Hm that is reversely related to dough stability; Vt, total volume of gas produced during three hours' fermentation; V_R, total volume of the gas saving at the end of time; R % (V_R/V_t), the gas retention coefficient.

2.6. Steamed bread preparation

Southern-style steamed bread was prepared according to the following procedure. The formulation of southern-style steamed bread prepared in this study was as follows: flour (LPF or LPF blended with bran of different particle size), 200 g; instant dry yeast, 2 g; and water (83% of Mixolab water absorption). Before dough mixing, yeast was dissolved in water (30 °C). And then yeast solutions was poured into wheat flour in the mixing bowl of a mixer (YCM, Ye Chang Instruments Co., Ltd, Shanghai, China) with a flat beater. Mixing was conducted at speed 1 for 4 min. After resting in a plastic bag at room temperature for 10 min, dough was sheeted 10–15 times on the sheeter (FKM-160, Jun Qifu Instruments Co., Ltd, Hebei, China) until the dough sheet surface was smooth. Then the dough sheet was rolled into a cylinder and stretched by hand to a length of approximately 100 cm. Next, the dough was divided into pieces of 25–30 g and proofed in a fermentation cabinet (FJ-YH, Shengheng Instruments Co., Ltd, Guangzhou, China) at 35 °C, 80% RH. Proof time was determined by dough volume increase. In this method, 25 g of steamed bread dough was placed into a 45 mL plastic centrifuge tube (3 cm in diameter). The initial dough volume was approximately 21–22 mL. After proofing, the final dough volume reached 38 mL. At this point, the proofed steamed bread dough was steamed for 15 min in a steamer (CFXB50A2A-80, Supor Instruments Co., Ltd, Zhejiang, China) and cooled at room temperature for 1 h before analysis.

Northern-style steamed bread was prepared according to the following procedure. The formulation of northern-style steamed bread prepared in this study was as follows: flour (MPF or MPF blended with bran of different particle size), 200 g; instant dry yeast, 2 g; and water (78% of Mixolab water absorption). Before dough mixing, yeast was dissolved in water (30 °C). And then yeast solutions was poured into wheat flour in the mixing bowl of a mixer (YCM, Ye Chang Instruments Co., Ltd, Shanghai, China) with a flat beater. Mixing was conducted at speed 1 for 6 min. Dough was fermented for 45 min at 35 °C and 80% RH in a proofing cabinet (FJ-YH, Shengheng Instruments Co., Ltd, Guangzhou, China). Then the fermented dough was rolled by hand. After resting in a fermentation cabinet (35 °C, 80% RH) for 15 min, the dough was steamed for 20 min in a steam chamber (CFXB50A2A-80, Supor Instruments Co., Ltd, Zhejiang, China) and cooled at room temperature for 1 h before analysis.