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Effects of wheat bran with different colors on the qualities of dry noodles

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ABSTRACT

White, blue, black and purple red wheat bran powders were prepared by ultrafine grinding to the particle size distribution of 0.5–100 μm. The effects of wheat bran addition on the qualities of dry Chinese noodles were investigated. Rapid Visco Analyzer results suggested that peak viscosity, hot paste viscosity, cool paste viscosity, breakdown viscosity and setback viscosity of the blends decreased with the increasing bran levels from 2.0% to 6.0% ($P < 0.05$). Color of dough sheet (L^*) decreased with the addition of wheat bran, while a^* and b^* values increased distinctly. Water absorption and firmness of the cooked noodles showed up trends with increasing addition of bran, while cooking loss showed a downtrend. Tensile strength and elongation rate decreased when bran addition was 2.0%, but increased when bran addition reached 4.0%–6.0%. Storage modulus (E') and loss modulus (E'') showed decreasing trends with increases in bran addition at frequencies of 0.1–10 Hz. SEM revealed that bran presence could slightly decrease surface connectivity between starch granules and gluten. It is possible to produce fiber-rich noodles by using 2.0%–6.0% ultrafine-ground bran in wheat flour.

1. Introduction

Wheat is the staple food in the world, cultivated in over 115 nations under a wide range of environmental conditions. Wheat bran is a by-product generated in large amounts during wheat processing, which consists of 36%–52% total dietary fiber (DF). DF is beneficial for human health by reducing the risks of developing chronic diseases such as cardiovascular disease, obesity, type 2 diabetes, and some cancers (Liu, 2007; Topping, 2007). Vitaglione et al. reported that bran is a key factor in determining whole grain health benefits (Vitaglione et al., 2008). The recent research demonstrated that lipophilic compounds from bran were cancer preventive agents (L. Liu et al., 2012; L.M. Liu et al., 2012). However, only about 10% of commercial wheat bran is used as a source of insoluble dietary fiber for breakfast cereals and bakeries. The remaining 90% of the wheat bran is sold as animal feed and as fertilizer at an extremely low price. Furthermore, wheat bran has higher vitamin and mineral contents than endosperm (Esposito et al., 2005), and high antioxidant content (Li et al., 2007; Liyana-Pathirana and Shahidi, 2007; Verma et al., 2008). These characteristics give wheat bran very interesting nutritional properties, and so the addition of bran to different types of foods has been studied extensively (Chillo et al., 2008; Gómez et al., 2011; Robin et al., 2011; Shenoy and Prakash, 2002). However, the use of wheat bran in the food industry is limited due to challenges in technological and sensory properties of the bran fraction (Mosharraf et al., 2009; Seyer and Gelinas, 2009).

In recent years, the possible use of ultrafine grinding in food research has attracted much attention (Zhu et al., 2010). The reduction of particle sizes of various materials to micro size leads to some changes in structure and surface area and brings new outstanding characteristics that bulk materials do not possess before. The physicochemical properties of wheat bran can be improved by ultrafine grinding. However, unfortunately, so far the use of this technology in wheat bran processing is rather limited.

Therefore, the objectives of the present study were: (1) to apply ultrafine grinding technology for producing wheat bran powder in the submicron range; (2) to investigate the effects of ultrafine grinding wheat bran on the qualities (color, water absorption, cooking loss, textural properties, dynamic viscoelastic properties, and microstructures) of dry Chinese noodles. This research was

Abbreviations: BDV, breakdown viscosity; CPV, cool paste viscosity; DF, dietary fiber; DMA, dynamic mechanical analyze; E', Storage modulus; E'', loss modulus; HPV, hot paste viscosity; PKV, peak viscosity; RVA, Rapid Visco Analyzer; SBV, setback viscosity; SEM, scanning electron microscopy; TPA, texture profile analysis.

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expected to give useful information on exploiting the potential applications of wheat bran in noodle manufacture for commercial practices.

2. Materials and methods

2.1. Materials

Wheat flour was purchased from Haijia Food Industry Co. Ltd. (Zhengzhou, China). White wheat, blue wheat, black wheat and purple red wheat were kindly provided by Department of Agronomy, Henan Agricultural University (Henan Province, China).

2.2. Preparation of wheat bran samples

Wheat samples were tempered to 15.5% moisture by adding an adequate amount of water for 20 h. Then the samples were roller-milled to straight-grade flours on a Buhler experimental mill (Buhler Co., Uzwil, Switzerland). The bran was micronized by using HM-701B nano-ball-milling (Beijing Tianyuan round-Mechanical Technology Co., Ltd., Beijing, China). Moisture content of the samples was determined by air–oven methods.

2.3. Particle size distribution

Particle size distribution of the bran after ultrafine grinding was determined using a GSL-101BI laser particle size analyzer in the working range of 0.1–450 μm (Liaoning Instrument Research Institute Co., Ltd., China). The samples were suspended in distilled water before taking the measurement. The analyses were carried out with constant stirring.

2.4. Pasting properties of the blends

The pasting properties of wheat flour with 0%, 2.0%, 4.0% and 6.0% wheat bran were determined using a super 4D Rapid Visco Analyzer (RVA) (Newport Scientific Instruments, Warriewood, Australia). Samples were prepared by mixing flour (3.0 g) and 25 mL distilled water. The analysis was conducted based on the AACC approved method 76-21.01 (2000b). The heating and cooling cycles were programmed in the following manner: The samples were held at 50 °C for 1 min, heated to 95 °C in 3.42 min, held at 95 °C for 2.7 min, cooled to 50 °C in 3.88 min, and held at 50 °C for 2.0 min. Peak viscosity (PKV), hot paste viscosity (HPV), cool paste viscosity (CPV), setback viscosity (SBV) and breakdown viscosity (BDV) were recorded.

2.5. Preparation of dry Chinese noodles

Noodle making dough was prepared by mixing 100 g flour, 2 g salt and different color wheat bran with 38 mL water to produce dough crumbs that were aggregated by hand kneading. The stiff dough obtained was passed through the sheeting rolls of a MT12.5 laboratory noodle machine (Henglian Food Mechanical Industry Co., Ltd., Guangzhou, China), sheeted four times using the 3.5 mm roll gap setting. The sheeted dough was rested in a plastic bag for 30 min at room temperature, and then successively sheeted using 2.5, 1.8, 1.3 mm, 1.1 mm, and 1.0 mm roll gap settings. The final dough sheet was cut to produce 2.0 ± 0.1 mm-wide and 1.0 ± 0.1 mm-thick noodle strips. The noodles were dried in a convection oven at 40 °C for 6 h with the humidity set at 70%, and then preserved in a preservative plastic bag at room temperature.

2.6. Color measurement

Color of wet dough sheets were determined by a Chromameter (Model SC-80C, Beijing Kangguang Optical Instrument Co., Beijing, China) using the Hunter scale for L^*, a^* and b^*. L^* value is a measurement of brightness (0–100); a^* value represents the red–green coordinates (− is green while + is red); b^* value indicates the blue–yellow coordinates (− is blue while + is yellow). Each data represents the mean of three replicates.

2.7. Water absorption of the noodles

Dry noodles (10 g) were boiled in 300 mL of boiling water until the white core inside the noodles disappeared. After boiling, the noodles were placed in cool water for 5 min. Then the noodles were placed on the filter paper for 5 min to remove the excess water. Water absorption of the noodles was calculated by the following equation:

$$\text{Water absorption } (\%) = \frac{M_1 - M_2 \times (1 - W)}{M_2 \times (1 - W)} \times 100 \qquad (1)$$

where: M_1 is the weight of noodles after cooking (g); M_2 is the weight of noodles before cooking (g); W is the moisture content of noodles before cooking (%).

2.8. Cooking loss of the noodles

Cooking losses were determined by Approved Method 66-50 (AACC, 2000a) with some modifications. Cooking water after determining water absorption was evaporated and dried at 105 °C to a constant weight. Cooking loss was expressed as a percentage of dry matter lost during cooking to dry sample weight.

$$\text{Cooking loss } (\%) = \frac{M}{G \times (1 - W)} \times 100 \qquad (2)$$

where: M is the weight of dry matter (g); G is the weight of noodles before cooking (g); W is the moisture content of noodles before cooking (%).

2.9. Texture analysis

Textural analysis of cooked noodles was carried out within 5 min after cooking using a Texture Analyzer (TA. XT Plus, SMS Co., UK) equipped with the Windows version of Texture Expert software (Stable Micro Systems Ltd). Maximum shear force of the cooked noodles was tested. For the TPA (texture profile analysis), five cooked noodles were compressed using a Code A/LKD probe until the deformation reached 90% at a speed of 0.8 mm/s. To test the tensile strength, cooked noodles were fixed to the arms of tensile grips. Force (tensile strength) at the break point was measured at a speed of 2.0 mm/s. Five measurements were conducted for each sample. Moreover, the width and thickness of the noodles were determined to calculate the cross-sectional area. The tensile strength and elongation rate were calculated by the following equation:

$$\text{Tensile strength} = \frac{F}{A} \times 100 \qquad (3)$$

where: F is the force at the break point (g); A is the cross-sectional area of noodles (m^2).