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Improvement of the quality of steamed bread by supplementation of wheat germ from milling process

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A B S T R A C T

Wheat germ, an important by-product in the flour milling industry, is known for its nutritive value. This study investigated the effects of wheat germ supplementation on the quality of steamed bread. Raw wheat germ (RWG) or defatted wheat germ (DWG) was added to wheat flour at compositions of 1–11% (w/w). Results showed that RWG supplementation increased the wet gluten content of dough, but decreased the gluten index of steamed bread compared to the raw flour. However, opposite trends were observed by addition of DWG. Both RWG and DWG had generally similar effects on disulfide bond content. The color test showed that high levels of wheat germ were associated with a decreased L^* value and an increased b^* value. The a^* values stayed close to a light red color irrespective of germ type. Sensory evaluation ratings and textural analysis indicated that steamed bread with acceptable quality attributes can be prepared from wheat flour fortified with wheat germ at less than 3%.

1. Introduction

Enhancing the nutritional content of traditional staple foods has become a priority. These fortified foods are important to many populations throughout the world (Beg et al., 2001; Elleuch et al., 2011; Shah et al., 2006). Steamed bread, or 'man-tou' is a staple food of China, representing about 40% of China's wheat consumption (Kim et al., 2009). Its main ingredients are wheat flour, water and yeast. Dough for steamed bread is usually made from fermented flour, and the product is cooked in a steamer over boiling water to produce a roll-sized product with a smooth, white skin and no crust. The porosity varies from dense to open, and taste varies according to consumer preference.

Production of steamed bread has some advantages over Western-style bread. Maillard reactions take place during the baking process for Western bread, causing a loss of soluble amino acids and reducing nutritive value. Acrylamide, which may be carcinogenic to humans, forms during baking. However, this toxin is not formed during steaming at lower processing temperature and atmospheric pressure (Becalski et al., 2003). Steamed bread offers another dimension to bread choices due to its delicate texture and pure wheat fragrance. In China, consumers prefer fresh, nutritional and healthy products, and steamed bread is eaten throughout the day (Rubenthaler et al., 1990). However, the defect of lysine and vitamins in steamed bread may cause malnutrition among consumers without enough supplement of vegetables, fruits or dairy products (Xiao et al., 2014).

Wheat germ is a high nutritive by-product of the flour industry. It is characterized by a high protein content, mainly in the form of albumins and globulins, and a more balanced amino acid composition, which repairs the defects of cereal proteins (Sun et al., 2008; Zhu et al., 2011). The germ also provides 6 times more minerals, 7 times more fat and 15 times more sugars than does wheat flour (Brandolini and Hidalgo, 2012). Furthermore, wheat germ is relatively rich in protein, B-vitamins, dietary fiber and unsaturated fatty acids (Bansal and Sudha, 2011; Leenhardt et al., 2008; Olah et al., 2007). In particular, antioxidants in wheat germ are useful to prevent cardiovascular diseases and cancer (Pérez-Jiménez et al., 2008). Therefore, wheat germ offers an appropriate medium to convey these benefits to the human diet. Despite these attributes, wheat germ is mainly used in animal feed, which has few commercial uses and has not been efficiently used.

In recent years, more cereal-based foods have been enriched with wheat germ or its derivates. Bread is popular throughout the world. Some previous studies have investigated the effects of raw wheat germ (RWG) on bread quality, while others incorporated defatted wheat germ (DWG) or toasted wheat germ. Results showed that wheat germ not only enhanced the nutritive value of bread (Rizzello et al., 2011; Sidhu et al., 1999; de Vasconcelos et al., 2013), but also affected the characteristics of dough and bread

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(Majzoobi et al., 2012; Shin et al., 2013; Siddiq et al., 2009). A product with acceptable quality could be made with appropriate formula modifications or process optimization (Gómez et al., 2012; Sidhu et al., 2001; Srivastava et al., 2007).

Quality requirements for steamed bread differ from those of pan breads, including the distinct attributes of color, hardness, elasticity, cohesiveness and smoothness associated with the traditional product. The quality of steamed bread is also related to other attributes, such as lower moisture in dough (45–50%, flour-weight basis), less fermentation time, steaming instead of baking, and smaller specific volume than pan bread. These attributes endow some differences in the physicochemical and sensory characteristics of bread. However, few studies have evaluated the quality of steamed bread supplemented with wheat germ, and the difference in properties in terms of RWG and DWG are not known.

Therefore, this study investigated the wet gluten content, gluten index and disulfide bond content of dough, as well as the color, texture and sensory qualities of steamed bread supplemented with different amounts of RWG and DWG.

2. Material and methods

2.1. Materials

Commercial wheat flour (13.5% moisture, 0.48% ash, 13.0% protein, 23.8 ml sedimentation value, 420 s falling number, 58% water absorption, 4.2 min dough development time, 4.3 min dough stability, 128 ICC breakdown time and 57 mm farinograph quality number) and active dry yeast (Angel brand, Hubei, China) were procured from a local market. Wheat germ was gifted from Shandong Flour Mill (Shandong, China). After contaminants were removed, RWG was soaked in 15-x volume of n-hexane at room temperature for 2 h. The solution was then filtered and insolubles were recovered, followed by soaking with another 15-x volume of n-hexane. The defatting process was repeated until the supernatant was colorless. The resulting DWG was then consecutively air-dried at room temperature for 24 h. Both the RWG and DWG were milled in a laboratory hammer mill (JXFM110, Shanghai Jiading Grain and oil equipment co., LTD, Shanghai), screened through 100-mesh (average particle size of 158 μm and 150 μm for RWG and DWG, respectively), and kept in sealed bags at 4 °C until use.

2.2. Dough and steamed bread preparation

Batches of 100 g mixed flour (14.0% moisture base), 1 g active dry yeast and variable water were mixed at low speed for 5 min using a Hobart mixer A-120 (The Hobart Manufacturing Company, Tory, Ohio). Variable water content was about 80% of the Farinograph water absorption. In brief, 46.4 ml of water was added for the control bread (46.6, 46.7, 46.8, 46.9, 47.0, 47.2 and 47.4 ml water was added for 1, 2, 3, 4, 5, 7, 9 and 11 g/100 g RWG breads, while 47.2, 47.4, 47.5, 47.6, 47.8, 47.9, 48.0 and 48.2 ml water was added for 1, 2, 3, 4, 5, 7, 9 and 11 g/100 g DWG breads, respectively). Dough was leavened in a fermenting box for 1 h at 38 °C and 85% RH. The dough was sheeted at 3.5 mm 15 times (HL-110, Guangdong Hengji Co. Ltd, Guangdong, China), rolled into a long, cylindrical shape by hand, and divided into pieces of a specified weight (100 g pieces), forming a round shape. Finally, the dough pieces were steamed for 30 min in a steamer and boiling water (S26B5, Supor Co., Ltd., Zhejiang, China). Steamed bread was covered with gauze and cooled at room temperature for 60 min before quality evaluation. Each dough treatment was processed in duplicate.

2.3. Chemical analysis

Moisture, ash, protein were determined following standard AACC methods (1983). Fat content was determined according to the AOAC method (1984). Total carbohydrate was determined with the phenol-sulfuric acid method (Dubois et al., 1956). Glutathione content was determined with the enzymatic recycling method (Rahman et al., 2006). All analyses were performed in triplicate.

2.4. Gluten and disulfide bond of dough

The wet gluten content and gluten index were determined according to the approved method 38-12 (AACC, 1995) with the Glutomatic 2200 system (Perten Instrument AB, Stockholm, Sweden).

The disulfide bond content was determined with the Opstvedt method (Opstvedt et al., 1984). Triplicate samples containing about 30 mg of protein were dissolved in a mixed solution (8.0 ml 0.2 M Tris buffer (pH 8.2), 0.02 M EDTA and 2% SDS) for 2 h, 0.5 ml of 0.016 M DTNB [5,5′-dithiobis(2-nitrobenzoic acid)], and 31.5 ml of absolute methanol was then added with mixing. The final solution was placed in covered tubes at room temperature for 15 min, centrifuged at 3000 g for 15 min and filtered. The absorbency was recorded at 415 nm, for calculation of native –SH groups.

The total SH was determined after the $NaBH_4$ reduction. The previously determined native –SH groups were then subtracted to obtain the number of disulfide bonds. Triplicate samples containing about 35 mg of protein were added to 4.0 ml of 0.6 M $NaBH_4$ in 8 M urea with 2 drops of octyl alcohol. After standing for 3 h, the remaining $NaBH_4$ was destroyed by adding 1.1 ml of 2 N HCl. The solution was brought to pH 8.2 with 2 N NaOH. To an aliquot of 0.5 ml of 0.2 M Tris buffer (pH 8.2)–0.02 M Na_2EDTA solution, 0.2 ml of 0.005 M DTNB, and 7.8 ml of absolute methanol were added. The solution was mixed and left to stand in covered tubes at room temperature for 15 min, centrifuged at 3000 g for 15 min, then filtered. The absorbency was 412 nm. These analyses were performed in triplicate.

2.5. Specific volume, color and texture of steamed bread

Bread volume was determined with the AACC rapeseed displacement method, 10-10B (AACC, 2000). The specific volume (ml/g) of the bread was determined as: bread volume/bread weight.

Color was measured with a Minolta CN-508i spectrophotometer (Minolta, Co. LTD, Tokyo, Japan) with the D65 standard illuminant and the 2° standard observer. Color values were recorded as L^* (0,black; 100, white), a^* (−100, green; +100, red), b^* (−100, blue; +100, yellow). Texture analysis was performed with a Texture Analyser (Model: TA-XT2i, Texture Technologies Corp., Scarsdale, New York), equipped with a 25 mm diameter aluminum cylindrical probe. Steamed bread was sliced horizontally, and a bottom piece of 25 mm height was compressed to 50% original height. Test conditions were as follows: pre-test speed 3 mm/s, test speed 1 mm/s, and post-test speed 5 mm/s. The analysis was performed in triplicate.

2.6. Sensory evaluation

Sensory evaluation of breads was conducted with 60 steamed bread usual consumer volunteers from 18 to 50 years of age and from food engineering backgrounds, consisting of Grain Oil and Food Science College staff and students from Zhengzhou, China. The tests were carried out in the Sensory Science Laboratory of the National Engineering Laboratory of the Henan University of