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Effect of wheat germ flour addition on wheat flour, dough and Chinese steamed bread properties

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ABSTRACT

Wheat germ flour (WGF) has been developed as a functional food ingredient with high nutritional value. In this study, WGF was applied in steamed bread-making in order to improve the quality of Chinese steamed bread (CSB). Partial substitution of wheat flour with WGF at levels of 3%, 6%, 9% and 12% (w/w) was carried out to investigate physicochemical properties of blends and their steaming performance. Falling number (FN) values of composite flours ranged from 199 to 223 s. Viscosity analysis results showed that wheat flour mixed with WGF had higher pasting temperature and lower viscosities. Dough rheological properties were also investigated using farinograph and extensograph. The addition of WGF diluted the gluten protein in dough and formed weak and inextensible dough, which can be studied by scanning electron microscope (SEM) analysis. CSB made with WGF had significantly lower volume, specific volume and higher spread ratio. The sensory acceptability and physicochemical quality of CSB were improved with the application of a low level of WGF (3% and 6%). However, results showed that a high level of WGF over 9% is not recommended because of unsatisfactory taste. As a whole, addition of appropriate level of WGF in wheat flour could improve the quality of CSB.

1. Introduction

Wheat (*Triticum aestivum* L.) is one of the most important crops and has been used as a main component to produce various food products. Wheat based foods play an important role in the food culture of Asian countries since ancient times. Chinese steamed bread (CSB) has 1700 years of history and is one of the most popular wheat products in China. With the passage of time, various types of CSB have been developed and most typical types are northern-style and southern-style steamed breads (Zhu et al., 2001). CSB is mainly constituted by wheat flour, water and yeast. Many other food ingredients such as bioactive compounds extracted from barley hull or flaxseed hull (Hao et al., 2012), custard cream, shiitake stipe, silver ear (Tsai et al., 2010), thermostable xylanase, lipid (Sun et al., 2010), sodium alginates and konjac glucomannan (Sim et al., 2011) have been used for CSB formulation to increase CSB diversity, nutritional value and product appeal.

Wheat germ, accounting for 2–3% of the total weight of wheat kernel, is almost removed during milling as it adversely affects the flour processing quality. It has been estimated that the world annual discarded wheat germ is up to 25,000,000 tons (Rizzello et al., 2010), which causes serious waste. On the other hand, most wheat germ is used for animal feed and other purposes, which makes human consumption of wheat germ very limited. During the milling process, wheat germ can be separated from the grain with high purity (Srivastava et al., 2007). It is rich in bioactive substances such as antioxidants and sterols. The antioxidants mainly include tocopherols, tocotrienols, phenolics and carotenoids (Gelmez et al., 2009). Wheat germ also contains some unsaturated fatty acids such

Abbreviations: WGF, Wheat germ flour; CSB, Chinese steamed bread; wt, weight; SEM, Scanning electron microscope; RVA, Rapid Visco Analyser; TV, trough viscosity; FV, final viscosity; PV, peak viscosity; BV, breakdown viscosity; SV, setback viscosity; FN, Falling number.

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as oleic, linoleic and α-linoleic acids (Rizzello et al., 2010). Moreover, most of the essential amino acids from wheat germ proteins are identified with higher concentrations than those in egg protein (Rizzello et al., 2010). Besides, wheat germ contains 10% oil which is applied in the medical and cosmetic industries (Kahlon, 1989). As for human health benefits, it is reported that the processed wheat germ can be applied in prevention and treatment of cancers (Zalatnai et al., 2001).

Wheat germ, which is rich in functional food components, and a viable potential wheat base ingredient might be used in food. Because of the high nutritional value, some studies considered the use of wheat germ for the manufacturing of cereal based food products. Pasta manufactured with semolina blended with 15% of raw and microwaved wheat germ showed significant increase of nutritional value (Pınarlı et al., 2004). Replacement of wheat flour with defatted wheat germ at levels of 0–25% also increased functional and nutritional properties in cookies (Arshad et al., 2007). Compared to breads made with refined flour, the concentration of minerals, proteins, fat and dietary fibers was higher in breads supplemented with wheat germ (Sidhu et al., 1999).

To our best knowledge, limited research is available on the physical properties and quality of CSB-making with WGF. Studies have reported the improvement of nutritional value of CSB after supplementation with WGF; however, the effect of WGF on the functional properties of the flour and the organoleptic acceptability of the CSB is rarely reported. Therefore, the objective of the current work is to investigate quality and nutritive value of CSB after supplementation of WGF. Additionally the extent of this improvement was also part of the investigation.

2. Materials and methods

2.1. Sample preparation

Wheat variety Pubing 9946, bred by Mr. Zhang Zhengmao in 2011 and harvested in 2013 in Yangling, Shanxi province, China, was used in this study. The wheat seed sample was first ground using a laboratory mill (LSM20, Maosheng milling apparatus, China). The flour contained protein (12.0%), ash (0.6%), moisture (12.1%), crude fat (1.3%) and wet gluten (40%). Flour was stored at 4 °C in polyethylene bags. Pure 9946 wheat flours or CSB made of pure 9946 wheat flours was used as control.

Wheat germ was obtained from a commercial mill (Laoniu milling plant, Yangling, China) and was dried in a baking oven at 70 °C for 2 h in aluminum trays (thickness of 0.5–1.0 cm). After roasting, the germ was emptied into a glass jar and cooled to room temperature, and then milled with particle size of 100 ± 200 μm. The samples were kept in sealed glass jars at 4 °C.

Mixed flours were prepared by mixing raw wheat flour at different levels of WGF (3, 6, 9 and 12%) to evaluate the physicochemical properties and steaming performance of the mixture.

2.2. Measurement of α-amylase activity

The α-amylase activity was measured according to the method of Khalil et al. (2000).

2.3. Pasting properties of starch

Pasting properties of starches in the wheat flours and the wheat germ flours were measured on a Rapid Visco Analyser (NEWPORT, RuA Super 3, USA) (Ragaee et al., 2006).

2.4. Rheological analysis

Measurements of water absorption, dough development time, dough stability and softening degree were carried out by using a Farinograph (Brabender, Germany). Dough extensibility and maximum resistance to extension were determined using an Extensograph (Brabender, Germany) (Hallén, 2004).

2.5. Microstructure observation

Microstructure observation was conducted according to Hu et al. (2009) with minor modification. Phosphate buffer (PB, 0.1 mol L^{-1}, pH 6.8) and ethanol solvents with ascending concentrations of 30%, 50%, 70%, 80%, 90% were used in this part.

2.6. Preparation of CSB

The formulation of CSB was as follows: wheat flour or the wheat germ flours (100 g), dehydrated yeast (1 g) and water (54 ml) were first prepared. After mixing and kneading into dough, the mixture was placed into the fermentation cabinet (38 °C and 85% R.H.) for 1 h. Dough was then taken out and sheeted 20 times followed by dividing it into several pieces (60 g per piece). The dough piece was rounded and molded manually and proofed for 20 min in the same fermentation cabinet. After that, the proofed dough was steamed for 25 min using a steam tray and boiling water.

2.7. Physical properties of CSB

The quality of CSB was evaluated by determining the weight, volume, width and height. Volume was measured after steaming 1 h by millet displacement method. The width and height of each sample was measured at different locations, and the average values were recorded. Specific volume (the volume to the weight, ml/g) and spread ratio (the width to the height, W/H) were calculated, respectively.

2.8. Textural analysis

Textural analysis was done by using a TA.XT PLUS/50 Texture Analyser (Stable Micro Systems, Ltd., UK) equipped with a P36 probe. Steamed bread was sliced horizontally and a bottom piece, 24 mm height, was compressed to 50% of its height. The test parameters were as follow: pre-test speed 1.0 mm/s, test speed 1.0 mm/s, post-test speed 1.0 mm/s and trigger force 5 g. From the TPA test profile, textural parameters including hardness, springiness, cohesiveness, adhesiveness and resilience were obtained.

2.9. Sensory evaluation of CSB

Sensory analysis of bread was carried out according to the method described by Haglund et al. (1998) with minor modifications. Elasticity, color, porosity, flavor, sweetness, dryness, taste and mouth satisfaction were evaluated using a scale from 0 to 10 points, with 10 being the highest score.

2.10. Statistical analysis

Data was collected from three duplicated experiments except for Farinograph and Extensograph. Statistical analysis of the results was implemented with software SAS 8.1 (Institute Inc., USA).