Industrial Crops and Products 61 (2014) 211–216

Contents lists available at ScienceDirect

Industrial Crops and Products

journal homepage: www.elsevier.com/locate/indcrop

Utilization of tartary buckwheat bran as a source of rutin and its effect on the rheological and antioxidant properties of wheat-based products

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ARTICLE INFO

Article history:
Received 5 February 2014
Received in revised form 10 June 2014
Accepted 1 July 2014
Available online 22 July 2014

Keywords:
Tartary buckwheat bran
Rutin
Rheology
Antioxidant activity

ABSTRACT

Tartary buckwheat bran, a by-product of buckwheat flour production was utilized as a source of rutin, and the extracted rutin-enriched material (REM) was used to fortify wheat-based foods of which rheological and antioxidant properties were characterized. REM contained a high content of rutin (29.6 g/100 g), compared to raw buckwheat bran (5.17 g/100 g). REM did not affect dough stability during mixing at room temperature. However, it reduced the thermo-mechanical properties of wheat flour in the dough system as well as the pasting parameters in the aqueous slurry during heating and cooling. When wheat flour was replaced with REM at 2, 4, and 6% in the formulation of wheat-based noodles, the products contained 0.28–1.35 g/100 g of rutin, satisfying the recommended daily dose of rutin. Moreover, REM provided antioxidant properties for wheat-based products by enhancing the DPPH radical-scavenging activity, ferric reducing ability power, and ABTS radical-scavenging activity.

1. Introduction

Rutin is a flavonol glycoside compound widely found in plants. Rutin is known to have beneficial health effects such as reduced blood pressure, lowered blood sugar concentration, and increased antioxidant activity (Zhang et al., 2012). It is interesting to note that rutin does not exist in cereals except for buckwheat (Min et al., 2010). Thus, as buckwheat is considered to be a major dietary source of rutin, it has received increasing attention as a potential functional food. Specifically, tartary buckwheat has 100 times higher amounts of rutin than common buckwheat (Yasuda, 2001). It is also reported that a higher content of rutin is included in buckwheat bran than in other milling fractions (Steadman et al., 2001). Unfortunately, when buckwheat grains are milled, buckwheat flour is only used for food applications, while their by-products—hull and bran fractions are discarded as waste. Therefore, there is a need to make an attempt to utilize buckwheat bran fractions as a good source of functional ingredients. However, no preceding trials have been made to obtain rutin-enriched materials from buckwheat bran to fortify wheat-based food products.

Several preceding studies reported the content of rutin in buckwheat-based products. For example, 6.76–7.84 mg/100 g and 44–47 mg/100 g of rutin were included in noodles (Kreft et al., 2006) and bread (Vogrincic et al., 2010), respectively. It is also noted that rutin content is distinctly reduced when buckwheat flour is mixed with water to make buckwheat dough (Suzuki et al., 2002). This phenomenon is related to the conversion of rutin to quercetin by rutin-degrading enzymes. Hydrothermal treatments have been applied to prevent rutin loss in buckwheat-based foods by inactivating the enzymes (Yoo et al., 2012). As mentioned, buckwheat flour has been only used as a source of rutin for food applications. However, it is insufficient to make a claim involving the health benefits of rutin from the intake of buckwheat flour due to its low level of rutin. It has been reported to take >500 or 40–100 mg of rutin per day for curative and preventive functions, respectively (Brunori et al. 2009). Furthermore, the lack of gluten in buckwheat flour can cause the problem of quality of final products. Therefore, there is a general tendency for buckwheat flour to be used together with wheat flour to minimize the undesirable quality changes. Therefore, if rutin-rich ingredients can be obtained, they will be readily

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http://dx.doi.org/10.1016/j.indcrop.2014.07.003
0926-6690/

incorporated into the formulations of various wheat-based foods, consequently allowing the food industry to develop new rutin-fortified products without a loss in quality.

This study aimed to utilize buckwheat bran—a by-product of buckwheat milling as a source of rutin. Tartary buckwheat grains were ground and separated into three fractions (hull, bran, and flour) in which rutin and quercetin levels were quantitatively analyzed by high-performance liquid chromatography (HPLC). The buckwheat bran was subjected to ultrasonic-assisted ethanol extraction in order to produce a rutin-enriched material. The resultant material high in rutin was then incorporated into the formulation of wheat-based noodles and its processing performance was evaluated from compositional, rheological, and antioxidant viewpoints.

2. Materials and methods

2.1. Preparation of a rutin-enriched material (REM) from buckwheat bran

Tartary buckwheat (*F. tataricum*) grains harvested in 2011 were provided from Bongpyeong Memil Farm (Bongpyeong, Gangwondo, Korea). Based on the study of Yoo et al. (2012), the grains were subjected to steaming over boiling water for 10 min in order to prevent rutin loss by rutin-degrading enzymes and then aerated overnight at 25 °C. They were ground by using a laboratory grinder (DA338-G, Dae Sung Artlon Co., Ltd. Seoul, Korea) and separated into three fractions (hull, bran, and flour) by passing through a series of sieves (Chung Gye Inc., Seoul, Korea). For rutin extraction, the bran fraction retained between two sieves (16 and 150 mesh) was suspended in 70% ethanol at a concentration of 40% (v/w) (The ethanol concentration and extraction time/temperature were determined from preliminary experiments). After sonication in an ultrasonication bath (42 kHz, BRANSON 5510, Branson Ultrasonics Corporation, CT, USA) for 30 min, it was agitated at 80 °C for 1 h in a water bath and centrifuged at 14,000 × *g* for 20 min. The supernatant was then dried at 60 °C.

2.2. Determination of rutin and quercetin

Quantitative measurements of rutin and quercetin were based on the method of Yoo et al. (2012). Buckwheat samples (0.5 g) were mixed with 70% ethanol (20 mL) at 80 °C for 1 h and placed at 4 °C for 1 h. After filtering through No. 41 Whatman filter paper, the levels of rutin and quercetin were quantitatively measured by using an Agilent 1200 series HPLC system (Santa Clara, CA, USA) equipped with a UV detector and Capcell Pak C18 column (UG120 S-5, Shiseido Co., Ltd., Tokyo, Japan). Components were separated at 30 °C with a linear gradient of methanol/acetic acid (95:5, v/v) (solvent A) and water (solvent B) with a flow rate of 0.5 mL/min. A solvent was applied from 10 to 60% for 40 min and then increased to 100% for 5 min. The absorbance was monitored at 350 nm and standard materials for rutin and quercetin were obtained from Sigma Aldrich (St. Louis, MO, USA).

2.3. Pasting measurement

The effect of REM on the pasting profiles of wheat flour was investigated by using a controlled-stress rheometer (AR1500ex, TA Instruments, New Castle, DE, USA) with a starch pasting cell. All-purpose wheat flour (CJ Co. Ltd., Seoul, Korea, 9.0% protein) was replaced with REM at 0, 2, 4, and 6% on an equal weight basis. The REM-wheat flour mixture was suspended in distilled water to produce a 10.5% slurry (28 g), which was subjected to a heating and cooling program (holding at 50 °C for 1 min, heating to 95 °C at 12 °C/min, holding at 95 °C for 2.5 min, cooling to 50 °C at 12 °C/min, holding at 50 °C for 2 min).

2.4. Mixolab thermo-mechanical measurement

The effects of REM on the thermo-mechanical properties of wheat flour in a dough system were investigated using a Mixolab (Chopin, Tripetteet Renaud, Paris, France). All-purpose wheat flour was replaced with REM at 0, 2, 4, and 6% by weight. The REM-wheat flour mixture was placed into a Mixolab mixing bowl and distilled water was added to obtain the optimum dough consistency (1.1 Nm). The programed temperature protocol was applied where dough samples were placed at 30 °C for 8 min, heated to 90 °C at a rate of 4 °C/min, held at 90 °C for 7 min, cooled to 50 °C at a rate of 4 °C/min, and finally placed at 50 °C for 5 min.

2.5. Preparation of wheat-based noodles with REM

The functional performance of REM was evaluated in a wheat-based noodle system. REM was incorporated into the noodle formulation that consisted of 50 g all-purpose wheat flour (CJ Co. Ltd., Seoul, Korea), 1 g NaCl (CJ Co. Ltd., Seoul, Korea), and 20 mL distilled water. All-purpose wheat flour was replaced with REM by 0, 2, 4, and 6% on an equal weight basis. All ingredients were mixed by using a KitchenAid mixer (5KSM150, KitchenAid, St. Hoseph, MI, USA) at speed 1 for 2 min with scraping down every minute, followed by hand-kneading for 2 min. The dough was sheeted with a sheeting roller (1.4 mm gap) and passed through a cutting roller to produce noodle strands (4 mm wide). The noodle strands (10 g, 4 mm wide and 10 cm long) were immersed in boiling water (150 mL) for 10 min and the cooked noodles were allowed to drain for 5 min.

2.6. Textural measurement

The changes in the tensile properties of the noodles prepared with REM were investigated using a texture analyzer (TMS-Pro, Food Technology Co., Virginia, USA) equipped with a Kieffer dough and gluten extensibility rig. Noodle samples were stretched with a hook at a speed of 3.3 mm/s. The maximum force and the distance at the extension limit were obtained.

2.7. Antioxidant activity measurement

The antioxidant activities of REM-incorporated noodles were determined in three ways—2,2′-diphenyl-1-picrylhydrazyl (DPPH), 2,2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS), and ferric reducing antioxidant power (FRAP) assays. Noodle samples were ground to pass through a 150 mesh sieve prior to antioxidant activity measurements. They were mixed with 70% ethanol at room temperature for 5 h and centrifuged at 15,000 × *g* for 20 min. Based on the method of Sun and Ho (2005), the ethanol extract (0.5 mL) was added to 0.1 mM DPPH solution in ethanol (0.5 mL) and then allowed to stand at 37 °C for 30 min. The absorbance was measured at 517 nm by using a spectrophotometer (DU 730, Beckman Coulter Inc., Fullerton, CA, USA). For the ABTS assay, ABTS solution (1 mL) prepared by the procedure of Zdunczyk et al. (2006) was added to the extract (0.01 mL) and the solution was incubated at room temperature for 6 min. The absorbance was measured at 734 nm. In addition, the extract (0.02 mL) was reacted with FRAP reagent (0.6 mL) for 6 min at 37 °C and then the absorbance was measured at 593 nm (Nilsson et al., 2005). The antioxidant activity was expressed as Trolox equivalents (TE) per gram of sample on a dry basis.