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Effect of green tea powder on the quality attributes and antioxidant activity of whole-wheat flour pan bread

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ABSTRACT

The effects of green tea powder (GTP) on the quality attributes and antioxidant activity of whole-wheat flour (WWF) pan bread were studied. Crumb hardness, cell diameter, and chewiness of WWF pan bread increased at higher GTP levels, whereas specific volume and brightness showed a reverse trend. At the 1.00 g GTP/100 g flour addition level, hardness, resilience and specific volume of WWF pan bread were not significantly affected, but antioxidant activity increased by 1.00 mM TE/g sample. In the storage test, GTP greatly inhibited the production of peroxide, as determined by peroxide value (PV), in WWF pan bread. After 8 days of storage at room temperature, the PV of the lipid fraction of WWF pan bread without GTP (control) increased by 0.35 mg/100 g, while the PV of bread with the addition of 1.00 g GTP/100 g flour increased by 0.14 mg/100 g. These results suggest that the addition of GTP at the 1.00 g/100 g flour level effectively increases the antioxidant activity, and significantly reduces the production of peroxide during storage, while at the same time maintaining the baking quality of WWF pan bread.

1. Introduction

Pan bread is one of the most widely consumed grain products in the world. Whole-wheat flour (WWF) pan bread is preferred by more consumers because of its high dietary fiber and bioactive substances, which not only reduce cholesterol levels but also decrease the risk of colon cancer (Lynnette & Philip, 1996; Okarter & Liu, 2010). To meet the growing demand for healthy and low-calorie foods, the development of bread products made with WWF, with its high content of dietary fiber and unsaturated fatty acids, could be an effective way to promote high-fiber food consumption and improve dietary patterns (Niu, Hou, Lee, & Chen, 2014; Mozaffarian, Lee, & Kennedy, 2013). However, the unsaturated fatty acids in WWF are susceptible to oxidation under high temperatures and/or light conditions, which decreases the nutritional value and makes the product unpalatable. The overall antioxidative capacity of whole wheat bread was reduced during storage as the lipid hydroperoxides were peaked after 2–3 weeks of storage (Jensen, Oestdal, Clausen, Andersen, & Skibsted, 2011). The addition of shortening in bread formulation could also contribute to the oxidation and might be considered as a source of oxidation products.

The oxidation of unsaturated fatty acids, monitored by peroxide value (PV), UV spectrophotometry, or high performance size exclusion chromatography of polar compounds of the lipid fraction (Bilancia, Caponio, Sikorska, Pasqualone, & Summo, 2007; Caponio, Gomes, Pasqualone, & Summo, 2007), reduces the shelf life of food products (Zhou, Chen, Zhang, Jiang, & Cao, 2002). Flour bleaching agent (i.e., benzoyl peroxide), bread improver (i.e., potassium bromate) and preservatives (i.e., calcium propionate) are frequently added to bread to improve quality and extend shelf life. However, such kinds of chemical additives may lead to acute or chronic poisoning (Varriano, Hsu, & Mahdi, 1980). At the same time, the requirements of consumers (in terms of flavor, nutrition and health) have become more stringent.

Tea is one of the most popular beverages in the world, and its strong antioxidant activity has drawn increasing attention in recent years (Mildner-Szkudlarz, Zawirska-Wojtasiak, Obuchowski, & Gośliński, 2009). Many researchers have reported that green tea contains antioxidant compounds (Karori, Wachira, Wanyoko, & Ngure, 2007), and have confirmed that green tea has stronger antioxidant ability than black tea (Lee, Lee, & Lee, 2002). Additionally, tea can prolong the shelf life of food products without

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affecting their organoleptic or nutritional qualities (McKay & Blumberg, 2002; Wang, Provan, & Helliwell, 2000). These biological properties are believed to result mainly from the functions of catechins (a major type of tea polyphenols that exhibits high antioxidant activity). Green tea powder (GTP) is powder-formed green tea leaves (ground powder, not instant tea powder), and retains almost all of the catechins of fresh tea leaves. In addition to bioactive components, GTP is a rich source of cellulose, proteins and vitamins. As a natural ingredient, GTP has been incorporated into a wide range of foods, such as biscuits, ice cream, and beverages (Liang & Lu, 2013), but it has never been used in pan bread, especially WWF pan bread.

The aims of this study were to investigate the quality characteristics of WWF pan bread with the addition of GTP at 0.00 g, 1.00 g, 2.00 g, 3.00 g, and 4.00 g/100 g flour levels, and to evaluate the antioxidant activity of GTP and its effect on the quality of pan bread. Additionally, a storage test at 37 °C (90 °F) and 65% relative humidity was conducted to evaluate the production of peroxide in the WWF pan bread.

2. Materials and methods

2.1. Materials

Hard white WWF was kindly provided by Ardent Mills (Denver, CO). Protein, moisture, lipids and ash contents of the flour were 12.70 g/100 g (14% mb), 8.70 g/100 g, 2.50 g/100 g (14% mb), and 1.60 g/100 g (14% mb), respectively. GTP was provided by Shao Xing Royal Tea Village Co. Ltd. (Shao Xing, Zhejiang Province, China). The mean particle size of GTP was 90 μm as measured by the laser particle-size analyzer (Haoyu Technology Co. LTD, Dan Dong, Liaoning Province, China). GTP was stored at 5 °C (40 °F) without light until further use. The contents of total phenolic, catechins, protein, vitamins C and E, and cellulose in GTP were 17.20 g/100 g, 12.90 g/100 g, 23.20 g/100 g, 0.80 g/100 g, and 24.10 g/100 g (dry basis), respectively. The antioxidant capacity of catechins is 1.46 mM TE/g.

2.2. Dough mixing properties

Dough characteristics were determined using the Mixolab (Chopin Technologies Inc. Paris, France). In the "Chopin+" protocol (AACC International Approved Method 54–60.01), the dough weight is 75 g, and the target consistency (C1) is 1.1 Nm (±0.05 Nm). The mixing tank temperature was maintained at 30 °C (86 °F) by a circulating water bath, and the mixing speed was 80 rpm. The time required to achieve C1 (T1), stability time, the torque of starch gelatinization (C3), the torque of hot gel stability (C4), and the torque of starch retrogradation in the cooling phase (C5) were measured.

2.3. Preparation of whole-wheat flour pan bread containing green tea powder

WWF breads were prepared according to the AACC International Approved Method 10-10B with some modifications. Bread formulation was: WWF (187.98 g, 14% mb), water (166.00 g), shortening (6.00 g), sugar (12.00 g), salt (3.00 g), non-fat dry milk (2.00 g), Lesaffre instant dry yeast (2.00 g), malted barley flour (0.40 g). GTP was added at the levels of 0.00, 1.00, 2.00, 3.00, and 4.00 g/100 g flour. WWF, GTP, and other dry ingredients were blended in a Swanson mixer (National Mfg. Co. Lincoln, NE) for 1 min. Water and shortening were added and mixed for ~6 min until the dough fully developed. The dough was divided into two 170 g pieces, placed in two lightly greased stainless steel bowls, and fermented in a fermentation cabinet (National Mfg. Co. Lincoln, NE) for 180 min at 30 °C (86 °F) and 85% RH. The fermented dough had its first punch at 105 min of fermentation, and its second punch at 155 min of fermentation. After 180 min of fermentation, the dough was molded with an Oshikiri molder (WFS, Oshikiri Machinery LTD, Tokyo, Japan), and placed into the baking pan and proofed for 60 min at 30 °C (86 °F) and 85% RH. The proofed bread dough was then baked at 204 °C (400 °F) for 26 min. After 60 min cooling at room temperature, bread was measured for volume and specific volume (volume divided by weight), and then cut mechanically into 20 mm-thick slices using a BIZERBA Bread Slicer (Model B100, Bizerba GmbH & Co. KG, Balingen, Germany) for crumb texture, color intensity and morphology measurement tests. The bread-making trials were replicated three times.

2.4. Pan bread quality analysis

2.4.1. Volume and specific volume

After cooling to room temperature for 60 min, bread weight was measured using a balance scale (Mettler Toledo, Schwerzenbach, Switzerland). Loaf volume and specific volume (volume divided by weight) were determined using a Bread Volume Measurer (Model: BVM-L370, TexVol Instruments AB, Viken, Sweden).

2.4.2. Color intensity and morphology of bread crumb

Color intensity was measured using the C-Cell (Model: CC.400.01; Calibre Control International Ltd. Warrington, UK) and was expressed as brightness, L^*, a^*, and b^* values. The lightness value (L^*) represents the black-white colors; a^* represents the green-red colors; and b^* represents the blue-yellow colors. Morphology of crumb grain was characterized by cell number, cell diameter, and wall thickness. The above-mentioned analysis was conducted in 10 replicates.

2.4.3. Texture profile analysis

The texture profile analysis (TPA) of bread was conducted using a TA-XTPlus Texture Analyzer (Texture Technologies Corp. NY) according to the method described by Fan, Yu, and Wang (2014). The bread slice (20 mm thickness) was placed on a flat Lexan plate and compressed to 30% of its original thickness at a speed of 3.0 mm/s using a 1 in (25 mm) diameter cylindrical acrylic probe (Model: TA-3); the compression was paused for 5 s after 30% compression. Hardness, springiness, chewiness and resilience were measured.

2.4.4. Antioxidant activity and peroxide value

Bread slices were packaged in plastic bags and sealed with an Impulse Heat Sealer (Model: MP-20, Midwest Pacific, Rocky Mount, NC). Slices in plastic bags were stored in an environment chamber (National Mfg Co. Lincoln, NE) at 37 °C and 65% RH for 8 d according to the procedure of Ren, Chen, and Jing (2011). Each treatment had three sets of bagged bread slice samples, and two slices were taken from each set at 0, 4 and 8 d, respectively. They were cooled for 20 min at −40 °C, followed by freeze-drying for 12 h at −80 °C. Later, the freeze-dried samples were ground to pass through a 60-mesh sieve for measuring antioxidant activity and peroxide value (PV).

2.4.4.1. Antioxidant activity. The antioxidant activity of the bread with different added amounts of GTP was determined by the 2, 2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS) assay method (Bae, Lee, Hou, & Lee, 2014). ABTS solution (7 mmol/L) was prepared by dissolving ABTS (Sigma Aldrich, St. Louis, MO) in deionized water, and was allowed to react with 2.45 mM potassium persulfate in the dark at room temperature for 16 h. The ABTS solution was diluted with phosphate-buffered saline (0.01 mol/L, pH