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Effect of xanthan and guar gum on the pasting, stickiness and extensional properties of brown wheat flour/β-glucan composite doughs

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ABSTRACT

The use of dietary fiber enriched flour for bread making is steadily gaining importance because of its proven health benefits. The objective of the work was to assess the impact of xanthan (XG) and guar gum (GG) on the pasting profiles, stickiness and extensional properties of β-glucan incorporated brown wheat flour (BWF/BGC) composite dough systems. Water absorption of the blend flour increased significantly with increasing the concentration of hydrocolloids. Loading of both hydrocolloids (0.125–0.5 g/100 g) produced similar values of extensograph and stickiness parameters, nonetheless, it was observed that an addition of 0.25 g/100 g hydrocolloid could be effective to maintain a desirable dough texture. Biaxial measurement indicated that the incorporation of 0.25 g/100 g hydrocolloids improved the dough structure of BWF/BGC. The pasting viscosities of the blend dough including hot paste, cold paste and final viscosity increased significantly with increasing the hydrocolloids concentration. The pasting properties of BWF/BGC influenced by individual hydrocolloid, and the difference could be attributed by the complex formation among swelled starch, leached amylose and hydrocolloids.

1. Introduction

Health and wellness are associated with food consumption. Consumers' currently select a food with potential health benefits; they are eager to know the nutrient contents of the food and their functionality. Dietary fibers (DFs) and DF-enriched food products, increasing its market share because of these products have shown their health benefits. Consumption of DFs has been associated with a lowering risk of several diet related diseases including cardiovascular disease, obesity, diabetes, hypertension, and gastrointestinal disorders (Anderson et al., 2009). The incorporation of DF has been quite successful in the baking industry. Soluble dietary fibers such the mixed-linkage (1 → 3; 1 → 4) β-D-glucans was clinically proven to lower serum cholesterol leading to lower risk of cardiovascular disease (Wood, 2007). Also, the consumption of bread enriched with β-glucan reduced low-density lipoprotein (LDL) cholesterol and improved insulin resistance in patients with type 2 diabetes (Tosh, Brummer, Wolever, & Wood, 2008; Li & Nie, 2016).

The addition of DF strengthens the structure of dough within a limited level, and modifies the bread loaf volume, its springiness, the softness of the bread crumb and the firmness of the loaf (Fendri et al., 2016; Sangnark & Noomhorm, 2004). However, the addition of an excess amount of DFs produces an inferior quality of bread texture due to dilution of gluten, and compatibility of water among dough constituents (Ahmed, Almusallam, Al-Salman, AbdulRahman, & Al-Salem, 2013). To compensate the negative textural attributes, hydrocolloids are added to DF enriched bakery products to maintain the desired texture. The addition of xanthan gum (XG) and guar gum (GG) could be used for recovering the gluten structure in a wheat flour/DF composite dough system. However, the mechanism of action of the hydrocolloids on wheat flour dough system is still not clear. It has been reported that carboxymethyl cellulose (CMC) is attached to the gluten while hydroxypropyl methylcellulose (HPMC) is bound to the outer part of the starch granules (Collar, Armero, & Martınez, 1998). Moreover, hydrocolloids could interfere either with the starch–gluten interactions or in the formation of physical entanglements (Davidou, Le Meste, Debever, & Bekaert, 1996). It is, therefore, interesting to understand the effect of individual hydrocolloid on the gelatinization process, and their impact on the pasting behavior, especially when starch, glutens and β-glucan are present in a blend surrounding

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water molecules that would help the baking industry to produce bread with an acceptable quality and sensory attributes. Furthermore, the developed dough can be extended further to frozen dough system, where added hydrocolloids have significant impact on bread volume, texture, staling rates, and reduce the physical damage induced by ice crystals (Barcenas & Rosell, 2006). A thorough investigation of hydrocolloids interaction within bread compounds would provide useful information for optimizing their addition.

This study has been designed to understand the effect of hydrocolloids (XG and GG) with a wide range of concentrations on texture and pasting performance of a blend of brown wheat flour (BWF) and β-glucan concentrate (BGC) dough during heating/cooling, so that the hydrocolloid concentration could be optimized for an optimal dough formulation.

2. Materials and methods

2.1. Materials

Commercial BWF produced by Kuwait flour Mills & Bakeries was used in this study with a proximate composition of moisture (8.3/100 g), protein (11.8 g/100 g), ash (1.68/100 g), and crude fat (5.11 g/100 g). BGC from barley was procured from Grain-Frac Consulting, Edmonton, Canada with a proximate composition of moisture (10.9/100 g), protein (11.6 g/100 g), ash (1.2/100 g), and crude fat (5.12 g/100 g). The β-glucan content in the concentrate was 21.65 g/100 g as determined by the mixed-linkage β-glucan assay kit (Megazyme International, Ireland), and the average molecular weight (Mw) of the sample was 1030 kDa as provided by the manufacturer. Xanthan gum (XG) from *Xanthomonas campestris*, and guar gum (GG) were purchased from Sigma-Aldrich (St. Louis, USA).

2.2. Hydrocolloids and dough preparation

A stock solution of XG and GG solutions were prepared by adding 1 g of powdered sample in 100 ml of warm water, mixed well for an hour with continuous stirring in a beaker. A required volume of hydrocolloid solution (0.125, 0.25, 0.375 and 0.5 g/100 g) was added to the BGC/BWF blend, and the water volume was adjusted accordingly.

2.3. Farinograph and extensograph measurements

The water absorption characteristics of the blend flours [BWF, BWF/BGC and BWF/BGC/hydrocolloids (HYC)] were measured by a farinograph (Model: 810130, Brabender, Duisburg, Germany), and the prepared doughs based on farinograph data were tested in an extensograph (Model 860704, Brabender, Duisburg, Germany), following the AACC standard method (AACC, 2000).

2.4. Dough preparation

The composite doughs were prepared in a Hobart mixer (N50 5-Quart Mixer) based on the farinograph water absorptions (Ahmed & Thomas, 2015). The hydrocolloid solutions were added instead of water for the BWF/BGC/HYC samples. Dough samples were packed in low density polyethylene (LDPE) bags and stored for textural and pasting measurement. A 100 g/100 g BWF formulation was used to understand the effect of BGC on dough.

2.5. Dough stickiness measurement

The texture characterization of dough was performed using a TA-XT Plus texture analyzer (Stable Micro-Systems, Surrey, UK) at 25 °C. Dough stickiness was measured at 25 °C using the SMS/Chen-Hoseney dough stickiness rig (A/DSC) and a 25-mm perspex cylinder probe (P/25P) (Stable Micro-Systems, Surrey, UK) attached to the Texture Analyzer following the method described by Ahmed and Thomas (2015). Dough stickiness data were documented as a force-versus-time curve. Dough stickiness was measured as a function of the added gum as described earlier and the holding time (30–90 min). The dough stickiness measured the positive maximum force (N).

2.6. Dough inflation system

Large strain biaxial extensional measurements of dough samples (BWF, BWF/BGC and BWF/BGC containing only 0.25 g/100 g GG and XG) were carried out by the Dobraszczyk-Roberts (D/R) dough inflation system mounted on the Texture Analyzer (Stable Micro Systems Ltd., Surrey, England) as described earlier by Ahmed and Thomas (2015).

2.7. Pasting properties

The pasting properties of flour dispersions (15-g flour/100-ml distilled water/gum solution) were measured by a Micro-Visco-AmyloGraph (Brabender, Duisburg, Germany), scaling both flour and water weight on a 14 g/100 g flour moisture weight. A programmed heating and cooling cycle was employed; the samples were heated from 50 °C to 95 °C in 15 min, held at 95 °C for 15 min before cooling to 50 °C in 15 min, holding at 50 °C for 15 min, and finally cooling to 45 °C. Viscosity was measured in Brabender units (BU). The peak viscosity (PV), hot paste viscosity (HPV), cold paste viscosity (CPV), and their derivative parameters breakdown (difference between the peak viscosity and the hot paste viscosity), setback (difference between the final viscosity and the viscosity attained after the first holding period), pasting temperature and peak time were obtained from the instrument software (Viscograph version 2.3.7).

2.8. Statistical analysis

All of the textural and pasting measurements were carried out in triplicate. The data were evaluated by analysis of variance (ANOVA), and a comparison of means was carried out with two sample *t*-test. Statistical analysis conducted using the R Stats package (Foundation for Statistical Computing, Vienna, Austria, 2013), and the differences were considered to be significant at a 95% confidence level ($P < 0.05$).

3. Results and discussion

3.1. Farinographic measurement

The water absorption (WA) of the BWF was significantly higher (64.6 g/100 g) than the white wheat flour (WWF) (54–59 g/100 g) ($P < 0.05$) as reported earlier by Ahmed (2015) and Gharaie, Azizi, Barzegar, and Aghagholizade (2015). The addition of 5 g/100 g BGC into BWF further increased the WA to 71.9 g/100 g, which was significantly higher than the WA value (65 g/100 g) shown by the WWF/BGC (95/5) blend as reported elsewhere (Ahmed, 2015). The farinograph properties of dough samples were significantly influenced by the type of the hydrocolloids (XG/GG) or its structure and the extent of this increase relied on the concentrations of the hydrocolloid added. An addition of 0.5 g/100 g XG to BWF/BGC blend increased the WA to 74.5 g/100 g. The observed WA was abnormally higher than the reported values for various hydrocolloids in dough matrix [0.5 g/100 g XG (56.7 g/100 g), 1 g/100 g gum tragacanth