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The comparison of the effect of added amaranth, buckwheat, chickpea, corn, millet and quinoa flour on rice dough rheological characteristics, textural and sensory quality of bread

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ABSTRACT

Gluten free (GF) flour (amaranth, buckwheat, chickpea, corn, millet and quinoa) was blended with rice flour to compare their impact on dough rheological characteristics and bread quality. The potential of some GF-rice blends in breadmaking has already been studied on blends with prevailing content of rice flour. The impact of added flour may be expected to rise with increasing amount of flour; therefore blends containing 30 g/100 g, 50 g/100 g and 70 g/100 g of GF flour in 100 g of GF-rice blend were tested. Under uniaxial deformation, peak strain was not impacted by the addition of GF flour; stress (12.3 kPa) was, however, significantly ($P < 0.05$) decreased (2.9–6.2 kPa). The reduction initiated by the presence of buckwheat, chickpea, quinoa and partly amaranth, together with thermally-induced dough weakening initiated by buckwheat and quinoa flour, may be related to significantly better crumb porosity. Overall acceptability of composite breads containing amaranth, chickpea and quinoa was negatively impacted by the aroma and taste of these flours. Higher potential to improve rice dough behavior and bread quality was found in the blend containing buckwheat flour (30 g/100 g; 50 g/100 g). Millet and corn flour deteriorated dough and bread quality.

1. Introduction

Food containing gluten must be eliminated from the diet of people suffering from celiac disease (Gallagher et al., 2004). The absence of gluten in breadmaking, however, brings technological problems. Compared to wheat dough, the tenacity of gluten-free (GF) doughs, as well as the ability to stretch is lower. GF doughs exhibit high viscous and elastic moduli are higher. Finally, GF dough viscosity during baking is not optimal (Burešová et al., 2014; Gujral and Rosell, 2004; Lamacchia et al., 2010). All these factors significantly impact dough ability to trap leavening gas, resulting in low GF bread volume, crumbly texture, crumb hardness, poor color, reduced shelf life and other quality defects (Anton and Artfield, 2008; Gallagher et al., 2004; Hager et al., 2012; Sivaramakrishnan et al., 2004).

Rice flour is usually preferred in GF breadmaking because of its colorlessness, nutritional characteristics, bland taste and low hypoallergenic properties (Gujral and Rosell, 2004). Blending rice flour with flours prepared from GF cereals or pseudocereals may result in improvement of bread quality. The potential of amaranth, corn and quinoa flour in rice bread production has already been described (Alvarez-Jubete et al., 2010; Sakač et al., 2011; Torbica et al., 2010). Although the improving impact of added flour may be expected to rise with increasing amount of added flours, the studies mentioned above were, focused on the evaluation of flour blends with prevailing content of rice flour. Additionally, higher portions of added nutritionally rich flours may also significantly improve nutritional quality of rice bread (Friedman, 1996).

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Disregarding the expected positive impact, the presence of typical flavor of some flours may not be acceptable for some consumers (Chávez-Jáuregui et al., 2003; Sindhuja et al., 2005). This paper was therefore focused on comparing the impact of 30 g, 50 g and 70 g/100 g of GF flours (amaranth, buckwheat, chickpea, corn, millet and quinoa) on the rheological characteristics of composite rice dough. Finally, the impact of added flour on sensory and textural characteristics of the composite rice bread was also compared.

2. Material and methods

2.1. Gluten-free materials

The research was performed on rice and GF flours (amaranth, buckwheat, corn, chickpea, millet, and quinoa) kindly provided by Extrudo Bečice, s.r.o., Czech Republic. The content of proteins, saccharides and fat in flours is summarized in Table 1. The following flour blends were prepared: 70 g of rice flour +30 g of GF flour, 50 g of rice flour +50 g of GF flour and 30 g of rice flour +70 g of GF flour. The flour amounts were related to 100 g of blend dry matter. Flour ratios were designed in accordance with the results of our previous research and the results published by Alvarez-Jubete et al. (2010); Sakač et al. (2011); Torbica et al. (2010).

2.2. Uniaxial elongational test

Most rheological tests are performed on doughs without yeast (Dobraszczyk and Morgenstern, 2003), thus dough samples were prepared according to the formulation used in breadmaking (see 2.4) without yeast. The dough was made into thin rolls, put onto the lubricated surface of a Teflon mold and compressed with a lubricated top plate. Test pieces were formed into 5 cm long chunks with a trapezoidal cross-section (3 mm, 5 mm, 4 mm). The doughs were left resting for 40 ± 1 min at 30 ± 1 °C. The test was performed using textural analyser TA.XT plus (Stable Micro Systems Ltd., UK) equipped with an SMS/Kieffer Dough and Gluten Extensibility Rig. During testing the dough sample was stretched by the hook until it fractured. Test speed of the hook was 3.00 mm/s, trigger force 5 g. The force required to stretch the dough sample and the displacement of the hook were recorded as a function of time. The curves were recalculated into stress-strain curves as described by Dunnewind et al. (2004). The stress-strain curves were characterized by peak stress σ_M and peak Hencky strain ε_{HM} at which the sample ruptured. Each test was performed on dough samples prepared at least in six replicates. The given results are represented as mean values.

2.3. Heating test

The thermally-induced changes of dough behavior may be measured by empirical mixolab; fundamental dynamic rheometry is, however, also applicable (Moreira et al., 2011). The main advantage of the latter method is greater precision and objectivity in the description of dough properties (Weipert, 1990). Additionally, Moreira et al. (2011) previously reported an acceptable agreement between the results obtained by mixolab and rheometry.

Oscillatory temperature ramp 30–90 °C at 0.058 °C/s was performed using HAAKE RheoStress 1 (Thermo Scientific, Czech Republic). The dough samples were prepared according to the formulation used in breadmaking (see 2.4) without yeast. After mixing, the dough was left to rest at 30 ± 1 °C for 5 ± 1 min in a sealed bowl. The sample was placed between 35 mm P35 Ti L parallel plates and compressed to a gap adjusted to 1.5 mm. The dough edges were afterwards trimmed with a spatula. The exposed side of the sample was coated with methyl silicone polymer Lukopren N1000 (Lučební závody a.s. Kolín, Czech Republic) to minimize dough drying out during the measurement. Temperature sweep test was performed at the strain of 0.1% and the frequency of 1 Hz within linear viscoelastic region. Thermally-induced changes of complex viscosity η^*, and peak complex viscosity η^*_{max} were evaluated. Finally, the parameters α, β and γ were used to characterize the angles between the ascending and descending parts of the complex viscosity curve (Fig. 1). Each test was performed on dough samples prepared at least in three replicates. The given results are represented as mean values.

2.4. Bread preparation

The dough was made from flour blend, water (100 g), saccharose (1.86 g), active dry yeast (1.80 g) and salt (1.50 g). The amounts of the ingredients were related to 100 g of blend dry matter. Saccharose was added to support fermentation (Mondal and Datta, 2008). Dry yeast was reactivated for 10 ± 1 min in a sugar solution (35 ± 1 °C). The dough ingredients were placed into an Eta Exclusive Gratus mixer bowl (Eta, a.s. Czech Republic) and mixed for 6 min. The prepared dough was scaled into bread pans and placed into a proofer for 20 min at 30 ± 1 °C and 85% relative air humidity. The loaves were baked for 20 min at 180 ± 5 °C in a steamy oven. Baked breads were removed from the pans and stored at room temperature (22 °C) for 2 h. Three batches of 3 samples were prepared for each flour as well as flour blend. The given results are represented as mean values.

2.5. Textural properties of bread

Textural properties of bread crumb were measured using texture profile analysis (TPA) on a texture analyzer TA.XT plus (Stable Micro Systems Ltd., UK). TPA was performed on samples 35 mm in diameter and 10 mm in height obtained from the center of each loaf. The sample was placed onto the analyzer base and squeezed twice to 4 mm with the 75.0 mm diameter cylinder probe P/75. Test speed of probe was 1.00 mm/s. The crumb parameters (hardness, stickiness, elasticity, cohesiveness and chewiness) were determined using ExponentLite software.

2.6. Bread crumb porosity

The bread crumb pictures were saved as bitmap files, with 300 DPI resolution in real-color format (RGB, 256 million colors). The images were then cropped to the resolution of 420 × 420 pixels. The cropped images were duplicated and one of each was converted into an 8-bit grayscale image. The grayscale images were thresholded using the software Paint Shop Pro (Corel Corporation, Canada), which allowed the conversion of the images into black and white colors. Pore number per image was calculated using the histogram tool in Paint Shop Pro.

Table 1
The content of proteins, saccharides and fat in g/100 g of flour dry matter.

Flour	Proteins	Saccharides	Fat
Amaranth	19.4	80.1	0.5
Buckwheat	11.1	86.9	2.0
Corn	10.4	85.3	4.2
Chickpea	25.4	68.9	5.6
Millet	11.9	83.3	4.8
Quinoa	19.0	74.7	6.3
Rice	7.9	91.6	0.5