EXTRUDED MAIZE FLOUR EFFECT ON THE QUALITY OF GLUTEN-FREE BREAD

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Abstract
Celiac disease is a common complex disease caused by a dietary intolerance to gluten proteins found in all wheat types and closely related cereals such as barley and rye (Heap, van Heel, 2009). The only effective treatment is a strict gluten-free diet throughout life (Gobbetti et al., 2003). Gluten-free breads often have poor crust and crumb characteristics, low quality, exhibit poor mouth feel and flavour (Katina et al., 2005, Gallagher et al., 2003). The aim of this research was to investigate the effects of extruded maize flour addition on quality of gluten-free bread. Four flour types (buckwheat, maize, rice, extruded maize) and six types of gluten-free breads made from buckwheat, maize and rice with or without extruded maize flour in various proportions were studied. The main quality parameters of gluten-free flour and breads were determined using the following methods: hardness with *Texture analyser TA.XT. plus*, moisture content with *Precisa XM 120* at temperature 110±1 °C, microstructure was observed using *Zeiss „Axioskop 40*" microscope and *Axioskop 4.7* software. Results showed that extrusion of maize flour has an effect on the size of starch granules, bread moisture, hardness and pore equivalent diameter. After partial flour replacement with extruded maize flour, it is possible to obtain gluten-free bread with more regular, stabile and porous texture.
Key words: Gluten-free bread, extruded flour, quality

Introduction
Cereal foods in various forms are an essential component of the daily diet. Nutritionally, they are an important source of carbohydrates, protein, dietary fibre, many vitamins and non-nutrients (Katina et al., 2005).

There is increase interest in gluten-free products as the number of the celiac patient grows and society is more informed about gluten-free products. Celiac disease is a common complex disease caused by a dietary intolerance to gluten proteins found in all wheat types and closely related cereals such as barley and rye (Heap, van Heel, 2009). The only effective treatment is a strict gluten-free diet throughout life (Gobbetti et al., 2003).

Gluten is the main structure-forming protein in flour, responsible for the elastic and extensible properties needed to produce good quality bread. To ensure the acceptability of gluten-free bread, the loaves must have quality characteristics similar to those of wheat flour bread (Gobbetti et al., 2003). Gluten-free bread is one of the most challenging issues for food technologists due to fact that wheat gluten has such a wide variety of tasks in bread making, so a wide range of ingredients is needed to achieve a good quality product without it and since a gluten-free diet is essential for patients having celiac disease. Gluten-free breads often have poor crust and crumb characteristics, low quality, exhibit poor mouth feel and flavour (Katina et al., 2005, Gallagher et al., 2003).

Many researchers has tried improving gluten-free bread quality using gluten-free flour mixtures (Sciarini et al., 2010, Torbica et al., 2010), additives such as hydrocolloids, gums, enzymes, emulsifiers (Renzetti et al., 2008; Peressini et al. 2011). Researchers from Brazil produced gluten-free bread using extruded rice flour as a gluten replacement. Results showed that the gelatinization of starch by extrusion could make the gluten-free bread production process viable and improve the colour of the crust and texture characteristics, which were similar to those of wheat bread, despite presenting a low specific volume (Clerici et al., 2009).

The aim of this research was to investigate the effects of extruded maize flour addition on quality of gluten-free bread.

Materials and Methods

White rice (moisture 9.09%), yellow maize (moisture 10.97%), buckwheat (moisture 9.53%) and extruded maize (moisture 6.69%) flour from Joint Stock Company “Ustukiu Malunas” (Lithuania), eggs, sugar, salt, apple vinegar, dry yeast and vegetable oil from local market were the materials used in study.

The general technological scheme used to make the gluten-free bread is presented in Figure 1. Six samples were prepared – maize bread (MB), maize bread with extruded maize flour (MBE), rice bread (RB), rice bread with extruded maize flour (RBE), buckwheat bread (BB), buckwheat bread with extruded maize flour (BBE).

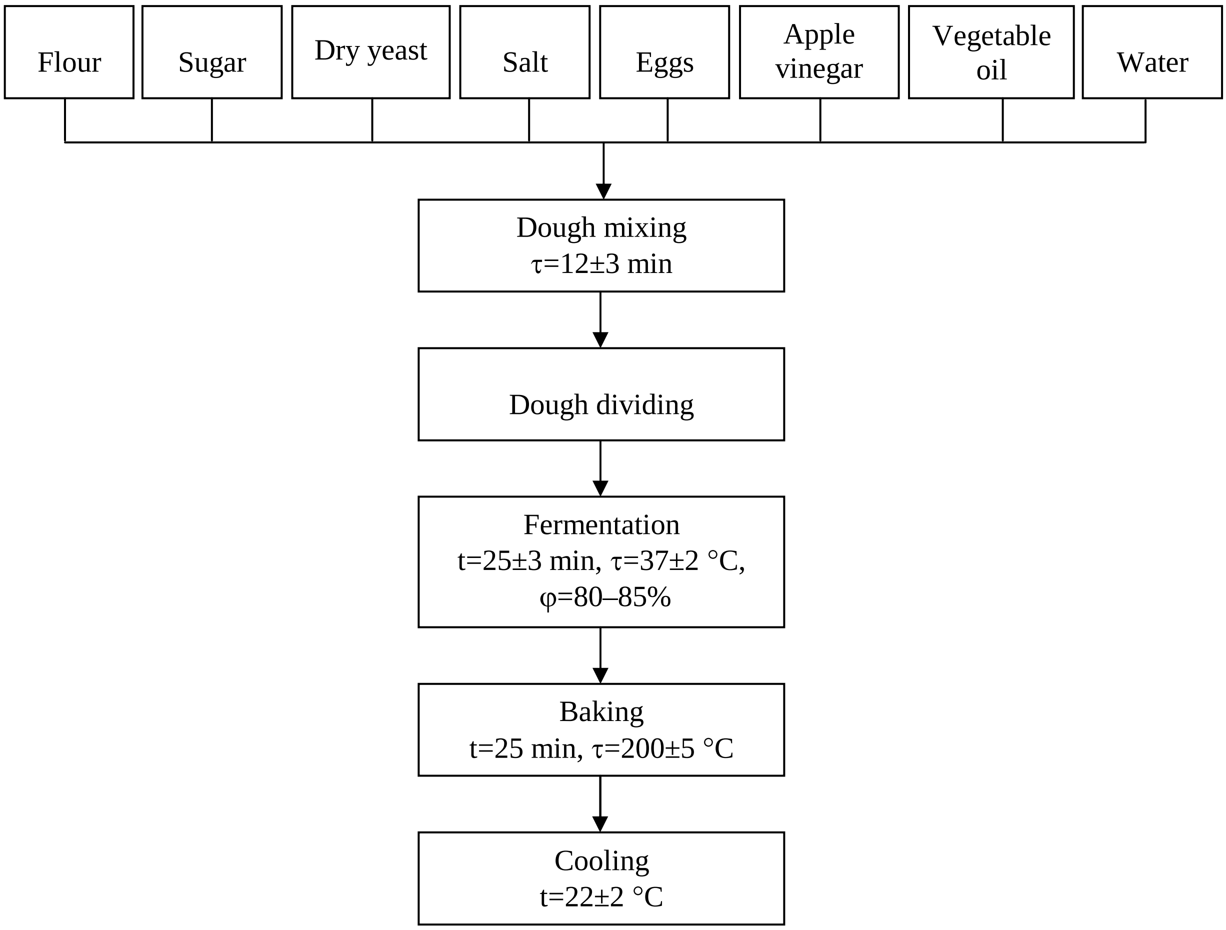


Figure 1. The general technological scheme of gluten-free bread

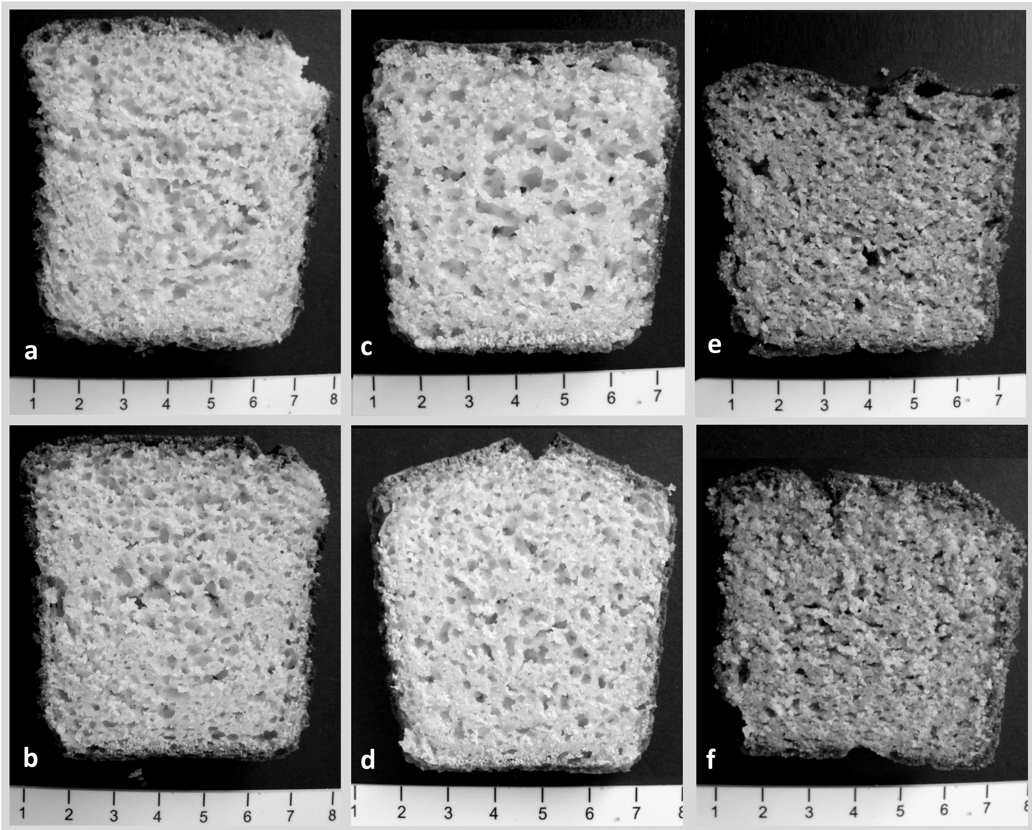
The hardness of bread slices (approximately 60×80×10 mm) samples was objectively measured using a Texture Analyser (*TA.XT. plus*, *Stable Micro Systems*) equipped with following compression test parameters: probe = 25 mm diameter aluminium cylinder, test speed = 1 mm s^{-1}, distance = 10 mm (Cauvain, 2004). Moisture content was analysed with *Precisa XM 120* at temperature 110±1 °C in two reiterations. Structure of bread samples and pores of bread crumb was analysed under the triocular microscope *Axioskop 40*. Pictures were taken by digital compact camera *Canon PowerShot A620* via 16x40 magnification of the microscope. Size and area of cells and starch granules was measured using software *Axioskop 4.7*.

Means and standard deviation of the means were calculated using Microsoft Office Excel 2007 (Microsoft Corporation, Redmond, WA).

Results and Discussion

During fermentation lead to further development of the dough structure and formation of gas cells. Yeast fermentation generates carbon dioxide, and the dough expands due to increasing pressure in the gas cells (Oates, 2001). Extruded maize flour affects gas cells stabilization and retention; it helps to develop regular porosity of gluten-free bread crumb (Figure 2).

The rice and buckwheat bread samples had the most significant impact of extruded maize flour on specific volume and porosity. Both samples had typical and regular specific volume and porosity (Figure 2c–f). In its turn the added amount of extruded maize flour did not affect the specific volume and porosity of maize gluten-free bread (Figure 2a–b).

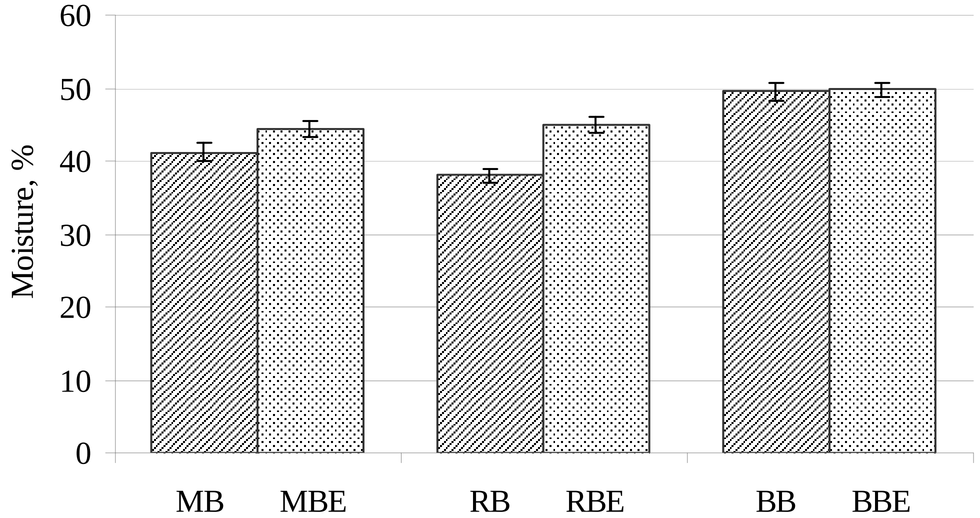


a - maize bread, b - maize bread with extruded maize flour, c- rice bread, d - rice bread with extruded maize flour, e - buckwheat bread, f - buckwheat bread with extruded maize flour

Figure 2. Digital images of gluten-free bread slices

An important parameter of bread quality is moisture, as it possesses the ability to bind and return water during the technological process (dough mixing, fermentation, baking and cooling). Figure 3 presents the moisture content of gluten-free bread samples.

Extruded maize flour has better water absorption capacity; it is associated with changes in starch granules during the extrusion. Consequently, the maize and rice bread samples with extruded flour moisture content were higher for about 3.25% (MBE) and 6.99% (RBE) (Figure 3). At the same time the added amount of extruded maize flour did not affect significant moisture content of buckwheat gluten-free bread (49.48% BB and 49.75% BBE). Unlike maize and rice, buckwheat contains more soluble proteins that affect its dough and crumb structure (Hong, Kim, 2006).

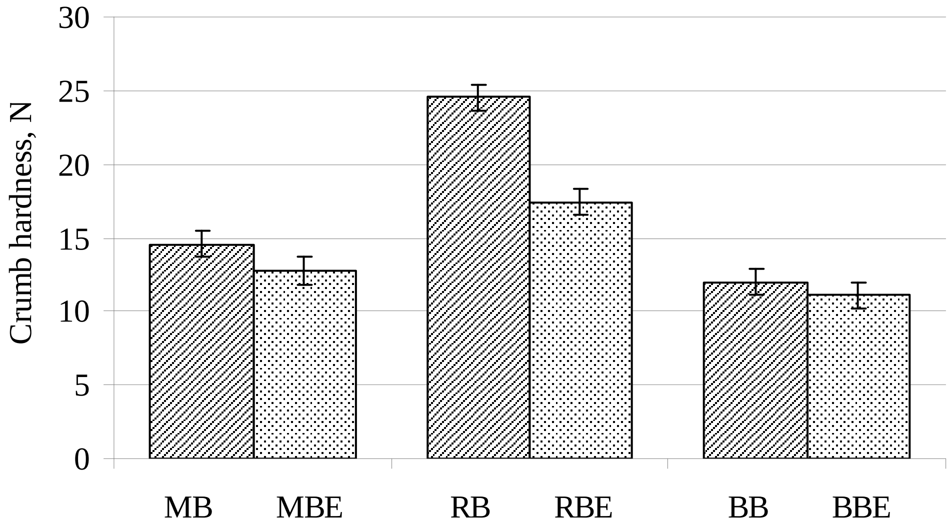


MB – maize bread, MBE – maize bread with extruded maize flour, RB – rice bread, RBE – rice bread with extruded maize flour, BB – buckwheat bread, BBE – buckwheat bread with extruded maize flour

Figure 3. Moisture content of gluten-free bread samples

Crumb hardness is closely related to bread moisture content, pore size and wall structure. Large pores with thick walls from stronger and less flexible crumb, but small, homogeneous pore structure develop softer and more flexible crumb (Oates, 2001). Figure 4 shows crumb hardness of the gluten-free bread samples.

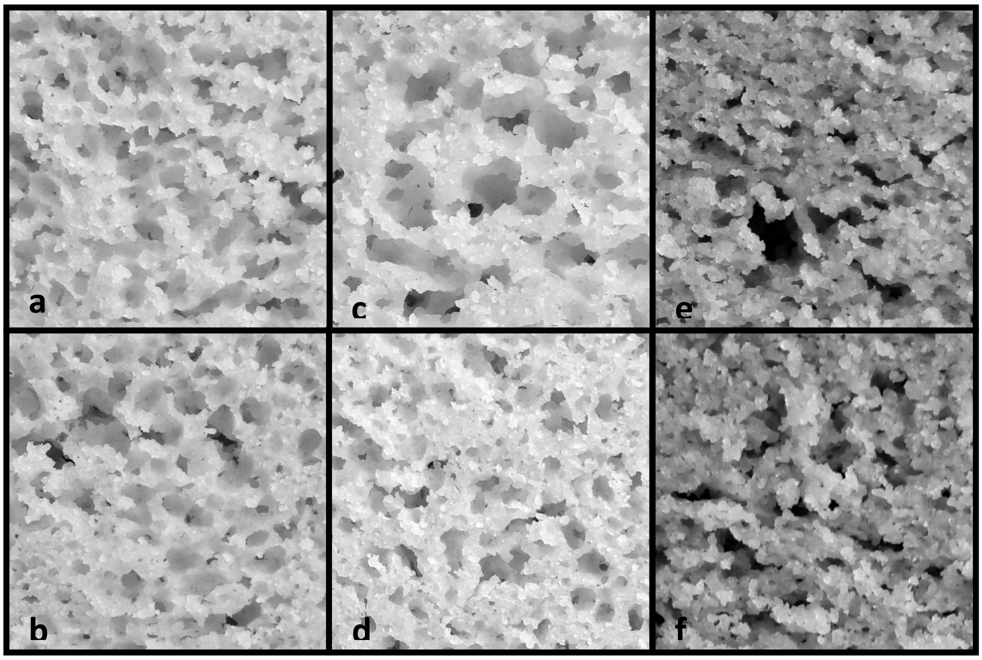
The obtained results shows that the gluten-free bread samples with extruded maize flour are 8.4% (BBE), 14.5% (MBE) and 40.9% (RBE) softer than the samples without extruded flour. Chemical composition of buckwheat flour which is characterized by lager soluble protein (Hong, Kim, 2006), partially explains the crumb hardness of the buckwheat gluten-free bread samples. Although rice flour contain small amount of protein, it contains a lot of starch (80%). All starch granules do not gelatinize and made bread crumb harder (Arendt, Nunes, 2010, Oates, 2001).



MB – maize bread, MBE – maize bread with extruded maize flour, RB – rice bread, RBE – rice bread with extruded maize flour, BB – buckwheat bread, BBE - buckwheat bread with extruded maize flour

Figure 4. Crumb hardness of the gluten-free bread samples

Optimally developed dough is one which the continuous and interconnected gluten matrix surrounds most of the starch granules. Association between starch granules and gluten proteins is affected by the quality of flour. Optimally developed dough contains occluded gas cells. The number and size of gas cells, which during baking expansion into open network of pores and determine crumb structure and volume, is influenced by mixing conditions and flour quality (Oates, 2001). Digital images of the gluten-free bread crumb samples are presented in Figure 5.
Both maize bread samples have a homogeneous pore structure. Pores of maize bread are characterized by thin walls and so close to each other that coalescence in one network (Figure 2a, 5a). Equivalent diameter of MBE pores decreased form 578.9 µm to 434.5 µm (Figure 2a–b, 5a–b). Crumb porosity of the maize bread samples with extruded flour (MBE) are homogeneous, because maize flour baking properties are similar to wheat.



a – maize bread, b – maize bread with extruded maize flour, c – rice bread, d - rice bread with extruded maize flour, e – buckwheat bread, f – buckwheat bread with extruded maize flour

Figure 5. Digital images of gluten-free bread crumb

Pores of rice bread are large with irregular structure, equivalent diameter 752.7 µm, added extruded maize flour improves porosity, equivalent diameter decreases to 620.1 µm (Figure 5c–d). Porosity of buckwheat bread samples is irregular pores are small and dense, more spaced along the crust (Figure 2e–f, 5e–f), equivalent diameter 587.8 µm. Added extruded maize flour decreased equivalent diameter to 420.9 µm, porosity of buckwheat bread with extruded maize flour is homogeneous with small and dense pores located all over crumb.

Conclusions

1. Moisture content in maize and rice bread samples with extruded flour was higher by approximately 3.25% (maize bread with extruded maize flour) and 6.99% (rice bread with extruded maize flour) comparing to bread without extruded maize flour.
2. Gluten-free bread samples with extruded maize flour are 8.4% buckwheat bread with extruded maize flour, 14.5% maize bread with extruded maize flour and 40.9% rice bread with extruded maize flour softer than the samples without extruded flour.
3. Porosity of gluten-free bread with extruded maize flour crumb becomes homogeneous, equivalent diameter of pores decreased on average form 639.8 µm to 491.9 µm.

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