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Chestnut flour addition in commercial gluten-free bread: A shelf-life study

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ABSTRACT

Two commercial gluten-free mixtures ($F1_{gf}$, and $F2_{gf}$) were enriched with 20 g/100 g and 10 g/100 g of chestnut flour, respectively, to produce technologically and nutritionally improved breads (M1C, M2C) to be compared to gluten-free breads (M1 and M2). Physicochemical (proximate composition, colour, texture, crumb grain characteristics) and nutritional (antioxidant capacity, in vitro digestion) indices were monitored during three days storage. The addition of chestnut flour led to colour browning, lower bulk volume with larger crumb holes and faster staling resulting from crumb cohesiveness and resilience decrease. M2C presented harder crumb and smaller holes compared to M1C, probably due to the lupine proteins in M2C. During storage, the crust hardness decreased (M1C) or increased (M2C) depending on mixture components, as consequence of different water migration. Higher antioxidant activity was observed for both the enriched breads while no variations resulted in starch digestibility. Finally, only breads with 20 g/100 g of enrichment showed a significant increase in total as well as soluble and insoluble fibres.

1. Introduction

Celiac disease (CD), an immune-mediated enteropathy caused by the ingestion of gluten in genetically susceptible individuals, is one of the most common lifelong disorders. At present, the only available treatment for CD is a strict gluten-free diet. The estimated prevalence of this disease is about 1% of the general population, and it affects persons of any age, race, and ethnic group (Fasano & Catassi, 2012). Recently, the market of gluten-free foods grew not only for the increment of CD incidence; consumers consider gluten-free foods appealing because they perceive these products as healthy, although no scientific evidences are still published about (Capriles & Arêas, 2014). Among gluten-free foods, bread is the most important. The development and/or improvement of gluten-free bread appear as a big challenge of food technology in view of the unique role of gluten in yeast-leavened baked goods and in bread-making process. The absence of gluten is well known to show a great influence on dough rheology also leading to bread with crumbling texture, poor colour, not satisfying taste and low specific volume (Houben Höchstötter, & Becker, 2012). Bread is also perishable; its integrity begins to deteriorate immediately after baking due to the chemical and physical changes that occur during the well-known staling process (Gray & Bemiller, 2003). Gluten-free breads are reported to show a short shelf-life, probably as a consequence of the lack of the viscoelastic network formed by gluten that is responsible for slowing down the movement of water (Houben, Höchstötter, & Becker, 2012). In the last years, different challenges (e.g. different gluten-free flours and starches, new additives, novel technologies) have been developed to overcome these problems, as reported in two interesting reviews recently published (Segura & Rosell, 2015 and references therein cited; Capriles & Arêas, 2014 and references therein cited). In this context, the point currently most debated in literature is the improvement of the nutritional value of gluten-free breads by adding ingredients with a high nutritional value, as the gluten-free dietary pattern is often characterised by an excessive consumption of fats and reduced intake of complex carbohydrates, dietary fibre, vitamins and minerals (Pellegrini & Agostoni, 2015; Segura & Rosell, 2011). The nutritional quality of gluten-free breads could be improved by incorporating nutrient-dense alternative flours and/or ingredients

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with the nutritional purpose of increasing fibres' content above all but also nutrients and phytochemicals such as g fruit- and vegetable-based ingredients (Capriles & Arêas, 2014). Fitting in with this outlook, in the last years chestnut flour received more and more attention due to its nutritional and health benefits both on wheat and gluten-free bread. Chestnut flour contains high quality proteins with essential amino acids (4–7 g/100 g), dietary fibre (4–10 g/100 g), low amount of fat (2–4 g/100 g) and also vitamin E, vitamin B group, potassium, phosphorous, and magnesium (Sacchetti, Pinnavaia, Guidolin, & Dalla Rosa, 2004). Dall'Asta et al. (2013) reported that wheat breads enriched with the addition of chestnut flour presented an increased quality from both organoleptic (more complex flavour, darker colour and more heterogeneous crumb) and nutritional (higher antioxidant capacity and fibre content) points of view. In addition, chestnut flour added breads showed a delay in the staling process, confirming the feasibility of producing bread with improved nutritional and qualitative characteristics, not only just after baking but also during shelf-life (Rinaldi, Paciulli, Dall'Asta, Cirlini, & Chiavaro, 2015). Regarding GF breads, Demirkesen, Mert, Sumnu, and Sahin (2010) studied the effects of different levels of addition on a rice-based gluten-free formulation reporting that elevated amounts of chestnut flour led to some deterioration in quality parameters. The same authors published several papers on chestnut flour addition in GF breads prepared on lab scale and mainly about the effects of cooking technique (Demirkesen, Sumnu, & Sahin, 2013a and 2013b). The use of commercial GF bread formulation was not considered. However, outcomes of these studies suggested that the replacement of rice flour with chestnut flour represents a promising way to enhance nutritional values of GF breads and, very interesting, to potentially retard staling of these kinds of bread (Demirkesen, Campanella, Sumnu, Sahin, & Hamaker, 2014). Thus, the aim of the present work was to evaluate the effects of chestnut flour addition on technological and nutritional properties of two common commercial GF bread formulations with complex recipes and already optimized from food industry for bread-making performances.

2. Materials and methods

2.1. Samples

Two common commercial (Biaglut, Latina, Italy) gluten free bread mixtures were used and ingredients, as reported on labels, were as follows: corn starch (43.5 g/100 g), potato starch (40.0 g/100 g), skimmed milk (6.5 g/100 g), destrose (4.5 g/100 g), cellulose (2.0 g/100 g), guar gum (1.8 g/100 g), hydroxypropylmethylcellulose (1.7 g/100 g) for the first mixture (named $F1_{gf}$) and corn starch (43.5 g/100 g), rice flour (40.0 g/100 g), lupine proteins (6.5 g/100 g), destrose (4.5 g/100 g), hydroxypropylmethylcellulose (2.0 g/100 g), vegetable fiber (2.0 g/100 g), salt (1.5 g/100 g) for the second (named $F2_{gf}$), The proximate composition (g/100 g d.m.) of the two mixtures were: $F1_{gf}$: carbohydrate 85.2., fibers 6.0, protein 4.4, fat 0.2; $F2_{gf}$: carbohydrates 84.3, fibers 7.1, protein 4.4, fat 0.8. A chestnut flour (C) was obtained as previously reported (Dall'Asta et al., 2013) from four cultivars (*Ampollana*, *Perticaccia*, *Leccardina* and *Gursona*) from the Ceno Valley (Parma, Italy) and so used for the enrichment It showed available carbohydrates, protein, fat and dietary fiber contents of 77.4 g/100 g d.m., 6.0 g/100 g d.m., 4.6 g/100 g d.m., and 12.0 g/100 g d.m., respectively. The commercial mixtures were used to prepare two control breads, coded as M1 from $F1_{gf}$, and M2 from $F2_{gf}$, respectively. Further two breads were prepared with a ratio of 200 g/kg C/$F1_{gf}$ (sample named as M1C) and of 100 g/kg C/$F2_{gf}$ (sample named as M2C), respectively. These chestnut flour ratios were selected based on previous results (Rinaldi et al., 2015) and preliminary experimentations.

2.2. Bread-making and storage

Breads were prepared with the following formulation on flour basis: M1 and M1C: flour (1 kg), water (880 g), sunflower oil (50 g), yeast (50 g) and salt (20 g); M2 and M2C: flour (1 kg), water (900 g), sunflower oil (50 g), yeast (50 g) and salt (20 g).

A domestic bread maker machine (Moulinex, Groupe Seb Italia S.p.A., Milano, Italy) was used for breadmaking, with the rapid program: stirring + kneading, + rising, 40 min; baking, 45 min at 210 °C. The breads were then cooled at room temperature. The loaves were packaged in alcohol-sprayed sealed air-tight plastic bags and stored in a 25 °C temperature-controlled chamber in the dark (ISCO 9000, Milan, Italy). Samples were analysed at 0, 1, and 3

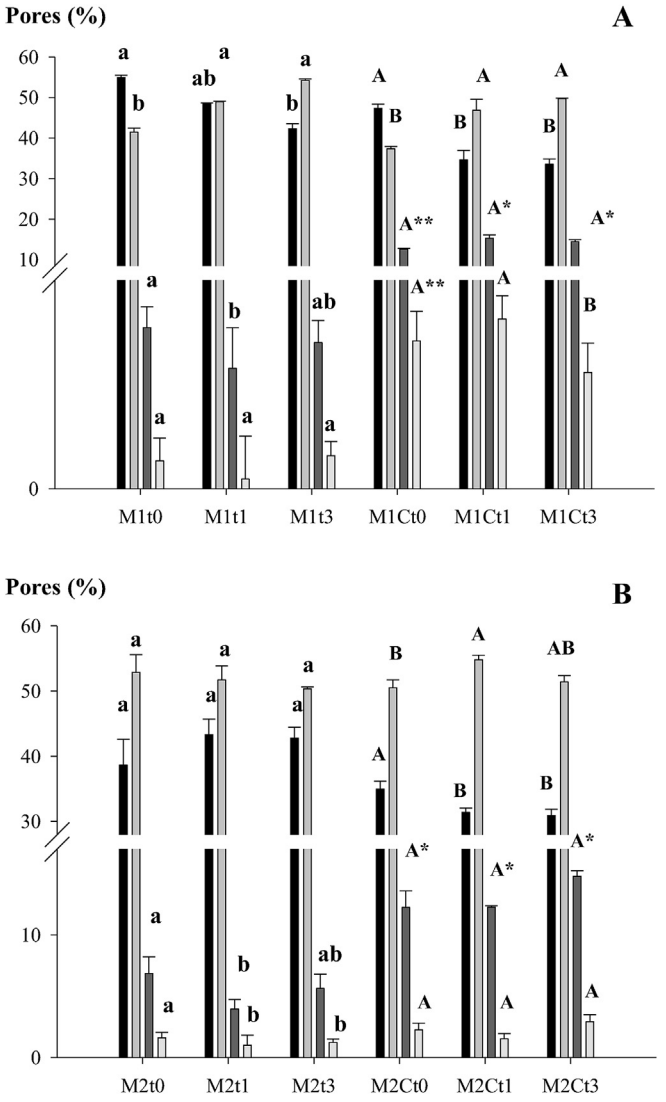

Fig. 1. Number of pores as percentage of the total number of pores for the selected dimensional classes (■ <0.05 mm^2; ■ 0,05–1.0 mm^2; ■ 1.0–5.0 mm^2; ■ > 5.0 mm^2). at different storage times for M1 and M1C (panel A) and for M2 and M2C (panel B) breads. Error bars represent ± 1 standard deviation, (n = 3, sample size = 3 for each bread type). Bars of histograms with the same lowercase and capital letters are not significantly different ($p < 0.05$). Bars with single ($p < 0.05$) or double ($p < 0.01$) asterisks differed significantly between breads made with the same mixture at the same storage time.