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Sprouted wheat as an alternative to conventional flour improvers in bread-making

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ABSTRACT

Sprouting is a natural process that enhances the nutritional and sensory profile of cereal-based foods. The present work addressed the possibility of using refined flour from sprouted wheat (SWF) to improve the bread-making performance of some flours in place of conventional improvers - i.e. enzymatic improver (EI) and malt (M). Either 0.5% EI or M was added to the control flour (CTRL), as conventionally used in bakeries, whereas SWF was used up to 2%. Unlikely EI and M, 1.5% SWF showed a gluten aggregation strength similar to that of the CTRL, suggesting no worsening of the protein network characteristics. As for the leavening properties, dough development increased, thanks to the enrichment with 1.5% SWF. In addition, presence of SWF improved the amount of gas production during leavening-resulting in bread with high specific volume - and the crumb softness during storage. Addition of SWF may represent a valid alternative to enzymatic improvers or malt for improving the technological performance of wheat flours.

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1. Introduction

During germination (or sprouting), high levels of hydrolytic enzymes - such as amylases and proteases – are accumulated in the cereal seed, so that the insoluble endosperm starch and protein reserves are hydrolyzed into soluble forms that can be transported to the embryo to meet the needs of the growing plant. Significant correlations between xylanase activity levels and sprouting-related parameters, such as α-amylase activity, and viscous properties of flour-water suspensions, have been reported (Dornez et al., 2008).

Under ideal growth conditions, ripe grains contain only small amount of enzymes and the resulted flour can be used to produce a wide range of cereal-based products. On the other hand, under non ideal conditions - e.g. when the grains are exposed to prolonged wet or foggy conditions – amylases, proteases, and xylanases may be retained or synthesized prior to harvest and as a consequence, the flour is unsuitable for baked products (Prasada and Hemalata, 2014).

Indeed, pre-harvest sprouted wheat is usually associated with dough weakening and stickiness, and with worsening of dough handling (Paulsen & Auld, 2004). Moreover, bread from extensively sprouted wheat show very poor characteristics, with a sticky and gummy crumb (McCleary & Sturgeon, 2002). Finally, the crumb color of the breads is darker and the grain and texture inferior compared to bread baked from non-germinated wheat (Finney et al., 1980).

On the other hand, since the nutritional (Hubner and Arendt, 2013; Singh, Rehal, Kaur, & Jyot, 2015) and sensory (Heiniö, Oksman-Caldentey, Latva-Kala, Lehtinen, & Poutanen, 2001) benefits of germination have been extensively documented, using of sprouted grains in food formulations is continuing to gain traction in the marketplace and represents a re-emerging trend in healthy foods.

Recent studies reported that the use of flour from whole wheat germinated in controlled conditions improved loaf volume and crumb texture (Bellaio, Kappeler, Rosenfeld, & Jacobs, 2014; Richter, Christiansen, & Guo, 2014). These positive effects were ascribed to the natural enzymes expressed during the germination process that might decrease or completely replace the quantity of commercial enzymes added to bread formulation. Nonetheless, the use of

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sprouted wheat as alternative to conventional flour improvers (e.g. enzymes, malt) has not been thoroughly investigated up to now.

Using enzymes as flours improvers is a frequent practice for flour standardization and also as baking aids. Enzymes – such as amylases, proteases and xylanases - are usually added to modify dough rheology, gas retention and crumb softness in bread-making (Goesaert, Gebruers, Courtin, Brijs, & Delcour, 2006). Those enzymes can be added individually or in complex mixtures, which may act in a synergistic way in the production of baked goods.

The present work addressed the possibility of using refined flour from controlled-sprouted wheat, as source of enzymes, to improve the bread-making performance of flours. The effects of the enrichment with low level (0.5–2%) of sprouted wheat on dough rheology and bread-making performance were assessed and compared to those of the improvers (e.g. malt and enzymatic improver) conventionally used in bread making.

2. Materials and methods

2.1. Materials

Flours from unsprouted wheat (USWF) and sprouted wheat (SWF) were kindly provided by Molino Quaglia (Molino Qualia S.p.A., Vighizzolo d'Este, Italy), as the commercial wheat flour (CTRL; $W = 260 \times 10^{-4}$ J; P/L = 2.08) used for blending studies. Malt (M; Malto 5, Bona s.r.l., Monza, Italy) and the enzymatic improver (EI, PowerBake950, Danisco, Copenhagen, Denmark) were added to CTRL at 0.5% level, which represents conventional amount used in bread-making (De Leyn, 2006). SWF was used at 0.5, 1, 1.5, and 2%.

2.2. Sprouting process

Commercial wheat kernels were sprouted in an industrial sprouting plant (Bühler AG, Uzwil, Switzerland). Wheat (10 tons) was soaked in water (kernels:water ratio of 1:2) for 12–24 h at 20 °C, germinated for 72–90 h at 20 °C, dried at 50 °C for 32 h. Unsprouted and sprouted wheat were milled in the same industrial plant (Bühler AG, Uzwil, Switzerland), and the related flours – USWF and SWF, respectively - were obtained.

2.3. Chemical composition

Moisture, starch, protein, lipid and ash contents were assessed by AACC standard methods (44–15.02, 76–13.01, 46–12.01, 30–10.01, and 08–01.01, respectively; AACC 2001). Sugars were determined by HPLC by Anion Exchange Chromatography with Pulsed Amperometric Detection (HPAEC-PAD) (Zygmunt et al., 1982). Total, soluble and insoluble dietary fiber content was quantified by enzymatic–gravimetric procedure (AOAC Method 991.43).

2.4. Enzymatic activities

Proteolytic activity was determined in triplicate in the conditions proposed by Arnon (1970) and using azocasein (Sigma Chemical Co., St Louis, MO, USA) as the substrate. Alpha-amylase activity was determined in triplicate according to AACC standard method n. 303, by using the Megazyme Amylase Assay Procedure (Megazyme International Ireland Ltd., Wicklow, Ireland). Xylanase activity was determined in triplicate using the Azo-wheat arabinoxylan kit (K-AZOWAX 09/04) provided by Megazyme (Megazyme International Ireland Ltd., Wicklow, Ireland).

2.5. Rheological properties

2.5.1. Pasting properties

Pasting properties were measured in duplicate using a Micro-Visco-Amylograph device (MVAG, Brabender GmbH & Co. KG, Duisburg, Germany). An aliquot of sample (12 g) was dispersed in 100 mL of distilled water and stirred at 250 rpm. The following temperature profile was applied: heating from 30 °C to 95 °C at a rate of 3 °C/min, holding at 95 °C for 20 min, cooling from 95 °C to 30 °C at a cooling rate of 3 °C/min, and holding at 30 °C for 1 min.

2.5.2. Gluten aggregation properties

Gluten aggregation properties were measured at least in triplicate using the GlutoPeak device (Brabender GmbH & Co. KG, Duisburg, Germany), as reported by Marti, Augst, Cox, and Koehler (2015).

2.5.3. Leavening properties

Leavening properties of doughs were assessed in duplicate with a Rheofermentometer® device (Chopin, Tripette & Renaud, Villeneuve La Garenne Cedex, France). Dough samples were prepared in an automatic spiral mixer (Bomann, Clatronic s.r.l., Piadena, Italy) with 1.5% NaCl and 1.5% bakers' yeast. Mixing time (1.6–1.8 min) and amount of water (54.5–55%) were those determined by the Farinograph test, according to the ICC Standard Method 115/1 (ICC 1992). The rheofermentographic test was performed on 315 g portion of the dough and carried out at 30 °C for 3 h.

2.6. Bread-making

Either wheat flour or blends were mixed with compressed yeast and salt, each comprising 1.5 g/100 g of the total mixture, and previously dissolved in water. The amount of water added to each formulation varied according to the farinographic water absorption index, previously determined. For each formulation, the ingredients were mixed in an automatic spiral mixer (Bomann, Clatronic s.r.l., Italy), for 8 min. Immediately after mixing, the dough was left to rest for 10 min at room temperature. After that, the dough was divided into portions of 250 g, molded into cylinder shapes, put in baking pans (8 × 15 × 5 cm) and left to rest for 60 min in a proofing chamber at 30 °C and 70% RH. Samples were baked in an oven (Self Cooking Center®, Rational International AG) for 4 min at 120 °C with vapor injection for 7 s. Then, the oven temperature was increased to 230 °C for 11 min. Two hours after removing loaves from the oven, they were packaged in perforated orientated polypropylene film and stored at controlled conditions (20 °C, 60% RH) for three days. For each sample, two baking experimental tests were performed and three loaves were obtained from each baking test.

2.7. Bread properties

A reflectance color meter (CR 210, Minolta Co., Osaka, Japan) was used to measure the lightness and saturation of the color intensity of bread crumb and crust. Each measurement was replicated five times and the average value was used.

The apparent volume (n = 6) was determined by the rapeseed displacement method, 2 h after baking. The weight of the bread (n = 6) was recorded and the specific volume was determined through the volume/mass ratio and expressed in mL/g.

Three central slices (15 mm thickness) were selected from each bread and used for crumb moisture, water activity, porosity and texture analysis.

Moisture content of the crumb was measured in triplicate by drying the sample at 130 °C until the weight will not change of 1 mg

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