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Effects of sourdough and enzymes on staling of high-fibre wheat bread

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Abstract

The effects of sourdough and enzyme mixture (α-amylase, xylanase and lipase) on the specific volume, staling and microstructure of wheat pan bread supplemented with wheat bran were studied. Staling of bread was followed for 6 days by measuring the crumb firmness, changes in crystallization of amylopectin (DSC), increase in signal from the solid phase (NMR) and by light microscopy. The most effective treatment in improvement of quality was the combination of bran sourdough and enzyme mixture. During storage the rate of changes in crumb firmness, amylopectin crystallinity and rigidity of polymers were greatest for the white wheat bread. The most pronounced microstructural changes were swelling of starch granules and separation of amylose and amylopectin in the starch granules. Least changes in crumb firmness, amylopectin crystallinity and rigidity of polymers were observed in bran sourdough bread with enzymes. In contrast to white wheat bread, the starch granules were very much swollen in bran sourdough bread with enzyme mixture. This was hypothesized to be due to the higher water content of bran bread, and degradation of cell wall components leading to altered distribution of water among starch, gluten and bran particles during storage.

Keywords: Bran; Sourdough; Enzymes; High-fibre baking; Shelf-life

1. Introduction

The nutritional importance of dietary fibre (DF) has been demonstrated in many studies. A typical Western diet contains less than 20 g/day, whereas the recommended daily intake is 25–30 g of DF (Cummings & Frolich, 1993). Thus, at the moment most people eat too little fibre and these low levels of DF in western diets contribute to a long list of diseases, ranging in severity from dental caries through constipation to obesity, colorectal cancer, coronary heart disease and type 2 diabetes. The most common source of DF in baking is cereal bran, especially wheat bran. Additions of cereal bran, however, especially in such amounts that health benefits can be expected, cause severe problems in bread quality. Acceptable loaf volume with high-fibre breads is difficult to obtain. Bran supplementation usually weakens the structure and baking quality of wheat dough and decreases bread volume and elasticity of the crumb. Addition of bran has been reported to decrease significantly loaf volume (Salmenkallio-Marttila, Katina, & Autio, 2001) and enhance firmness of bread (Laurikainen, Härkönen, Autio, & Poutanen, 1998). The deleterious effects of fibre addition on dough structure have been suggested to be due to e.g. dilution of the gluten network and presence of bran particles forcing gas cells to expand in a particular dimension (Gan, Galliard, Ellis, Angold, & Vaughan, 1992).

One option to improve quality of high-fibre wheat breads is to soak or ferment wheat bran before it is added to the dough or use commercial enzyme mixtures to overcome deleterious effects of bran on bread texture. Our earlier results demonstrated effectiveness of bran prefermentation in improvement of volume and softness

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of high-fibre wheat bread (Salmenkallio-Marttila et al., 2001). Furthermore, an improved softness of bran sourdough bread during 3 days of storage was observed, but the actual mechanism leading to improved shelf-life (and possible retarded staling) was not clarified.

Bread stales largely as a result of physical changes that occur in the starch–protein matrix of bread crumb. Retrogradation is the process by which starch amylopectin reverts to a more ordered state after gelatinization. Even though starch retrogradation has been shown to be the primary cause of bread firming, other components, particularly proteins, may affect the staling rate (Martin & Hoseney, 1991; Martin, Zeleznak, & Hoseney, 1991; Davidou, Le Meste, Debever, & Bekaert, 1996; Zobel & Kulp, 1996). Other dough components like pentosans, lipids, emulsifiers, sugars and enzymes also affect crumb softness of the fresh bread and the shelf-life.

Water content of dough and bread affects the properties of different chemical components of dough and bread. In the oven, heating rate of the dough piece and baking temperature affect the swelling and gelatinization of starch and, as a consequence the crumb structure. Water is assumed to have a significant role in the staling process. Water is more abundant in the swollen amorphous regions of starch, facilitating local polymer chain mobility (plasticization) and subsequent crystallization and retrogradation (Chinachoti & Vodovotz, 2001). Water distribution within regions in gluten, amorphous and crystalline starch is assumed to play an important role in starch and gluten rigidity.

Sourdough fermentation is used to improve the texture, volume and shelf-life of breads (Brümmer & Unbehend, 1997; Corsetti et al., 1998; Crowley, Schober, Clarke, & Arendt, 2002). Combined use of exogenous enzymes and sourdough in the same baking process has been reported to enhance rate of acidification, improve bread volume and retard white wheat bread staling (Martínez-Anaya, Devesa, Andreu, Escrivá, & Collar, 1998; Corsetti et al., 2000; Di Cagno et al., 2003).

The simplest method to follow staling is firmness measurements. However, in order to more thoroughly understand the molecular basis of staling and thus to be able to control it in bread, additional analytical tools such as thermal analysis, NMR spectroscopy and microscopy have been applied (Gray & Bemiller, 2003).

Aim of this study was to improve volume and shelf-life of wheat bread containing 10 g of DF/100 g of bread (dry weight) by utilization of bran sourdough, enzyme mixture, and by using of combination of these two. Influence of different treatments on the staling process of bran bread was elucidated by following the changes in the firming, the rigidity of polymers, crystallization of amylopectin and microstructure during storage.

2. Materials and methods

2.1. Materials

Commercial white wheat flour and wheat bran were used for baking (Melia Ltd., Raisio, Finland). The commercial coarse bran was further ground to obtain finer particle size (6% > 750, 47% > 355, and 78% > 132 μm). Chemical composition of the raw materials has been reported earlier (Salmenkallio-Marttila et al., 2001). Three commercial enzyme mixtures were used: α-amylase Grindamyl max-life (Danisco Ingredients, Denmark), Xylanase Pentopan mono BG (Novo Nordisk A/S, Denmark) and lipase Novozym 677 (Novo Nordisk A/S, Denmark).

2.2. Bran fermentation

For the fermentation, 100 g of bran was mixed with 350 g of water and with the dry microorganims (1.25 g of yeast, 0.162 g of *Lactobacillus brevis* L62) in a beaker and covered with aluminum foil. The starter culture of *Lb. brevis* L62 was obtained from Chr. Hansen, Denmark. Instant active dry yeast (Fermipan, Gist Brocades) was used for bran fermentation and baking. Bran was fermented for 16 h at 25 °C.

2.3. Baking and bread types

The following bread types were studied: (1) reference white wheat bread (WB), (2) reference bran bread (BB1), (3) bran bread with enzymes mixture (BB2), (4) bran sourdough bread (BB3) and (5) bran sourdough bread with enzyme mixture, combination treatment (BB4).

The recipe for the white reference bread (WB) was, in parts by weight, wheat flour (100), yeast (1.5), sugar (1.5), salt (1.5), fat (6), emulgator Panodan M2020 (contains diacetyl tartaric acid esters of mono- and diglycerides, Danisco) (0.48) and water (76). The amount of water was intentionally raised from the farinograph value (63 g of water/100 g of flour) in order to diminish influence of different water contents in the results. Ingredients were mixed for 8 min (3 + 5). After a floor time of 10 min (at +28 °C and relative humidity 76%) the dough was divided into 400-g loaves and moulded mechanically. The loaves were proofed in pans (55 min at +35 °C, RH 76%) and baked at 200 °C for 25 min.

The recipe for the bran reference bread (BB1) was, in parts by weight, wheat flour (80), wheat bran (20), yeast (1.5), sugar (1.5), salt (1.5), fat (6), emulgator Panodan M2020 (Danisco) (0.48) and water (76). The optimal water addition was determined by farinograph measurement. If bran sourdough was used (bran sourdough bread, BB3), 88 g of water/100 g of total dough water was prefermented with bran for 16 h (bran sourdough)