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Influence of particle size on bioprocess induced changes on technological functionality of wheat bran

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ABSTRACT

Wheat bran is nutritionally an important source of dietary fibre, vitamins and minerals, but its negative influence on dough rheology, texture and sensory quality of bread limits its use in bread baking. The current study aimed at improving the technological functionality of bran by bioprocessing Wheat bran of different particle size (750, 400, 160, 50 μm) was fermented 8 h or 24 h with *Lactobacillus brevis* E95612 and *Kazachstania exigua* C81116 with or without addition of enzyme mixture with various carbohydrase activities. Kinetics of growth and acidification showed that the growth of the starters was enhanced in the presence of enzymes in bran having particle size of 160 and 50 μm. Fermentation was critical to improve dough stability and volume of bran enriched breads, whereas addition of enzymes had the most significant effect in improving bread shelf-life. Wheat bread containing 160 μm bran fermented 8 h with enzymes had mild flavour, the highest volume and shelf-life. Reduction of particle size increased perceived smoothness of mouthfeel but provided darker colour in bran-containing breads. The short 8 h bioprocessing, with or without enzymes did not increase pungent flavour or bitter aftertaste in comparison with the native bran.

1. Introduction

Increased awareness of food healthiness has influenced grain processing in the recent years, and new technologies have been developed with the aim of producing foods and ingredients with improved nutritional quality. Wheat bran, obtained after conventional milling of wheat grains for the production of white flour, is an important source of dietary fibre, vitamins and minerals, but thus far mainly underutilized in food manufacturing. Despite the increasing evidence about the health effects of wholemeal and fibre-rich foods, most consumers still prefer refined white flour to whole grain products, because they perceive the textural properties of the last to be less attractive (Bakke and Vickers, 2007). In this sense, one of the most important targets to increase the consumption of healthy foods is by improving their perceived attractiveness. Development of new technologies to modify the sensory and technological properties of wheat bran and wholemeal flour could also diminish the differences in liking of whole grain vs. refined grain breads (Poutanen, 2012).

The main reason behind the low utilization rate of wheat bran in baking industry is the gritty texture, bitter and pungent flavour and coarse mouthfeel of bread caused by the bran (Zhang and Moore, 1999). Moreover, processing of dough with wheat bran is technologically very intractable. The addition of bran fractions to white flour has been shown to negatively affect both dough-mixing properties and bread-making quality and the effects on bread were strongly correlated to negative repercussions of bran on gluten network formation (Noort et al., 2010). Bran supplementation can affect the starch–gluten matrix, with effects on gluten dilution and protein hydration, negatively influencing the structure of wheat dough (Laurikainen et al., 1998; Rosell et al., 2006). Therefore, novel methods for dry-fractionation have been developed to improve bran performances in baking and for better exploitation of the nutritional potential (Delcour et al., 2012).

Reduction of bran particle size (micronization) has been applied to several fibre-rich plant matrices, in order to change structure, surface area and functional properties of the derived particles (Hemery et al., 2011). Wheat bran particle size is, however, a very controversial issue regarding its bread-making performance; some

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studies indicate that smaller wheat bran particle size gives better baking performance (Lai et al., 1989; Moder et al., 1984), while other researchers report that fine bran particle size has a detrimental effect on bread quality (Zhang and Moore, 1999; Noort et al. 2010). Reduction of bran particle size can improve technological and nutritional properties of flour (Bottega et al., 2009; Ferrari et al., 2009; Rizzello et al., 2012) and different methods for micronization of bran have been already considered (Hemery et al., 2007, 2011).

In addition to mechanical processing, bioprocessing techniques such as the use of hydrolytic enzymes and/or baker's yeast fermentation have been shown to be a promising approach to remove the technological drawbacks in bread making associated to wheat bran addition (Salmenkallio-Marttila et al., 2001; Katina et al., 2012). Bran bioprocessing with enzymes and yeast has also been shown to increase the content of bioactive compounds in bread with subsequent possible positive physiological effects (Mateo Anson et al., 2011). Combination of bran with amylolytic and phytate-degrading enzymes was successful in overcome the detrimental effect of bran on the mineral availability or on the technological performance of doughs (Sanz-Penella et al., 2008). Bioprocessing of bran by sourdough fermentation has also been shown to enhance nutritional features, as well as the textural properties of breads (Katina et al., 2007, 2012). However, the sensory properties of breads containing fermented bran have not been extensively elucidated and further studies are required to understand the impact of bioprocessing variables on sensory and texture-providing features of bran in baked goods.

The aim of this study was to assess the effect of particle size of wheat bran on bioprocessing-induced changes on bran and subsequent technological and sensory properties of bread containing bran.

2. Materials and methods

2.1. Raw materials

Commercial wheat bran (Fazer Mills, Lahti, Finland) was ground by TurboRotor technology (Mahltechnik Görgens GmbH, Dormagen, Germany) to three different levels of fineness. The median particle size of the four brans obtained, analysed by sieving, were: 750 (unground), 400, 160 and 50 μm, as provided by the supplier. All the four brans were used in bioprocessing and baking trials. Total DF content of the brans were 48.0% (750 μm), 48.9% (400 μm), 47.9% (160 μm) and 48.4% (50 μm), respectively measured according AOAC 9852. Commercial wheat flour (Sunnuntai, Raisio, Finland) of medium-coarse particle size was used, having Falling number 250, ash content 0.7%, wet gluten 26%, protein, 12%, fat 2%, DF 3%. Baker's yeast (Suomen Hiiva, Lahti, Finland), table salt (Meira, Finland), margarine (Raisio, Finland) and tap water were also used in the baking experiments.

2.2. Bran bioprocessing

Lactobacillus brevis E95612 and *Kazachstania exigua* C81116 belonging to VTT Culture Collection (VTT, Technical Research Centre of Finland) were used as starters for fermentation. *L. brevis* was cultivated for 24 h at 30 °C on MRS (Oxoid LTD, Basingstoke, Hampshire, United Kingdom) at anaerobic conditions, while the yeast was cultivated for 24 h at 25 °C in YM (3 g/l malt extract, 3 g/l peptone, 10 g/l dextrose). After the late exponential phase of growth was reached, cells were recovered by centrifugation (10,000 × *g* for 10 min), successively washed twice in 0.05 M phosphate buffer, pH 7.0, and re-suspended in tap water (ca. 15% of the initial volume of the culture). Bran doughs having wheat bran and water ratio of 20/80 were produced, containing lactic acid bacteria and yeast both at a final cell density of ca. 10^6 cfu/g. Enzyme preparations Depol 740L (Biocatalyst Ltd., Great Britain) and Grindamyl 1000 (Danisco, Denmark) were mixed with bran at the beginning of fermentation. The enzymes used contained a variety of hydrolytic enzymes, mainly xylanase, endoglucanase and β-glucanase in Depol 740L (Mateo Anson et al., 2009), and alpha-amylase in Grindamyl. Enzymes dosages were: 161 nkat xylanase/g of bran for Depol 740L (xylanase activity according to Bailey et al., 1992), and 75 nkat α-amylase/g of bran for Grindamyl 1000 (n α-amylase activity according to Megazyme Ceralpha method). Bioprocessing of bran was carried out inoculating the two starters without and with the addition of enzymes, as described above. Fermentations were carried out using Termarks incubators, KBP6151, Norway at 20 °C for 8 or 24 h. After fermentation, bran doughs (or bioprocessed brans) were used for bread making.

2.3. Microbiological analysis and kinetics of growth and acidification

Bran samples (10 g) were homogenized with 90 ml of sterile saline in a Stomacher 400 lab blender (Seward Medical, London). Serial dilutions were made and enumeration of lactic acid bacteria and yeasts was carried out by plating on MRS and YM agar after incubation for 48 h at 30 °C or 25 °C respectively. Kinetics of growth and acidification were determined and modelled in agreement with the Gompertz equation as modified by Zwietering et al. (1990): $y = k + A\exp\{-\exp[(\mu_{max}\text{ or }V_{max}\,e/A)(\lambda - t)+1]\}$; where y is the growth expressed as log cfu/g/h or the acidification rate expressed as dpH/dt (units of pH/h) at the time t; k is the initial level of the dependent variable to be modelled (log cfu/g or pH units); A is the cell density or pH (units) variation (between inoculation and the stationary phase); μ_{max} or V_{max} is the maximum growth rate expressed as Δlog cfu/g/h or the maximum acidification rate expressed as dpH/h, respectively; λ is the length of the lag phase measured in hours. The experimental data were modelled by the non-linear regression procedure of the Statistica 8.0 software (Statsoft, Tulsa, USA).

2.4. Chemical and rheological properties of doughs

The pH value was measured by a TitroLine autotitrator (Alpha 471217, Schott, Mainz, Germany) suspending an aliquot of 10 g of fermented bran in 100 ml of distilled water. For the determination of TTA, this suspension was titrated with 0.1 M NaOH to a final pH of 8.5 with the TitroLine Alpha autotitrator. TTA was expressed as the amount of NaOH used (ml). All samples were analysed in duplicate. Lactic and acetic acids were determined with commercial enzymatic assay (Boehringer Mannheim/R-Biopharm).

Farinograph (Farinograph-E, Brabender Measurement & Control Systems, Germany) was used to measure water absorption, dough development time (DDT) and dough stability. Temperature of measurement was 30 °C and speed of mixer was 63 min^{-1}. The weight of a measurement was 50 g and the duration time was 20 min. Thirtyfive grams of wheat flour and 15 g of bran in different particle size (15% level of addition) were used for each measurement. The dough consistency was run at 500 BU. Water addition of dough was determined from softening degree from the following equation:

$$\text{Water absorption}(\%) = \text{added water}(\%) - \frac{\text{softening degree}[\text{BU}]}{20[\text{BU}/\%]}$$

CO_2 holding capacity and dough development were measured by Chopin Rheofermentometer (Model F3, France). For wheat