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Effect of the addition of bran fractions on bread properties

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ABSTRACT

High fibre breads were produced adding durum wheat bran fractions of different composition and particle size. Fresh products were characterized for texture, crumb grain, volume, colour, water status (water activity, moisture content, frozen water content, ^{1}H molecular mobility).

The addition of bran fractions with different composition resulted in significantly harder samples with lower volumes as compared to the control (STD), while bran fractions with different particle size did not significantly affect the volume and hardness of the samples (comparable to STD).

The addition of bran fractions with different composition and particle size resulted in an altered water status, as shown by crumb moisture content (~43% vs ~41% in STD), water activity (0.97 vs 0.96 in STD) and frozen water content (~60–66% vs ~51% in STD). ^{1}H NMR data showed an altered ^{1}H molecular mobility in bran breads as compared to STD. In particular, an additional ^{1}H T_2 population was found in the bran samples. This population has been related to the influence of bran on starch-gluten-water interactions.

1. Introduction

A proper intake of dietary fibre may have multiple beneficial effects on human health as it can help preventing coronary heart disease, hypertension, diabetes, obesity, gastrointestinal disorders and positively affect the serum lipid concentrations, blood pressure, blood glucose control in diabetes and immune functions (Redgwell and Fischer, 2005). Bread, being a staple food for the western population, if properly formulated, may be a vehicle to increase fibre intake maintaining familiar nutritional habits. According to the European legislation (Regulation (EC) .1924/2006, 2006), a bread enriched with fibre can be defined as a high fibre product (and, therefore, able to promote beneficial physiological effects when consumed) if contains at least 6 g of fibre in100 g of product.

The presence of fibre in bread is known to affect the rheological properties of the dough (Wang et al., 2002), interfere with gluten formation (Rojas et al., 1999; Rosell and Foegeding, 2007), influence bread stability (Santos et al., 2008), and modify the macromolecular and molecular water distribution and dynamics (Gray and Bemiller, 2003). Many studies have investigated the effect of the addition of different sources of fibre to bread, such as wheat bran (Gan et al., 1992; Lai et al., 1989a; Seyer and Gelinas, 2009; Zhang and Moore, 1999), cellulose (Gómez et al., 2003; Wang et al., 2002) and chitosan (Kerch et al., 2008). Wheat bran addition in bread formulation results in a reduction of loaf volume, an increase in crumb firmness, a dark crumb appearance, a higher water dough absorption and a reduced fermentation tolerance (Gan et al., 1992; Lai et al., 1989a). Some of these effects have been attributed to the dilution of gluten, which would affect the gas-holding capacity of the dough (Gómez et al., 2003; Wang et al., 2002). It has been also reported that the competition of bran for water with starch and gluten might hinder a sufficient hydration of gluten resulting in the reduction of the loaf volume (Lai et al., 1989a,b).

A negative effect of bran particle size on dough-mixing properties, bread-making quality and loaf volume was reported by De Kock et al. (1999) and Noort et al. (2010). It is well known that the status of water in bread has a very important role in defying its properties and its shelf-stability and that water dynamics are affected by product's formulation (Baik and Chinachoti, 2001; Gray and Bemiller, 2003; Sereno et al., 2007; Serventi et al., 2009; Vittadini and Vodovotz, 2003). To the authors' best knowledge no reports have been published on the effect bran or of its fractions on the molecular mobility of water in fibre enriched bread. Molecular mobility has been, therefore, studied with low resolution NMR spectroscopy that has been previously applied in cereal based model systems and, in particular, in white bread (Bosmans et al., 2012; Curti et al., 2011; Engelsen et al., 2001; Wang et al., 2004).

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NMR spectroscopy has been applied, in this work for the first time, to high fibre breads to investigate the influence of fibre (bran) on molecular mobility. In particular, six high fibre breads were produced and characterized to investigate the effect of bran with different composition and different particle size on breads physico-chemical properties.

2. Material and methods

2.1. Bran fractions production and characterization

Three durum wheat bran fractions with different composition were obtained by a selective milling of bran at different degrees from the outer bran layer towards the aleuronic layer. Three additional bran fractions were obtained by milling durum wheat bran to different degrees to progressively reduce their particle size. All bran fractions were obtained with an industrial milling operation to be directly transferable to a commercial product.

Bran fractions were characterized for their composition with the following methods: AOAC International (1995), AOAC International (2003), oven drying at 105 °C to constant weight (water) and AOAC International (1995). Starch content was calculated as the difference to 100 (percentage). Particle size distribution of bran samples was measured by sieving bran on different size sieves into 7 dimensional classes.

2.2. Bread formulation, production and storage

Bread samples produced with the bran fractions with different composition were named C1 (more external layer bran fraction), C2 (intermediate layer bran fraction) and C3 (more internal layer bran fraction). Bread samples obtained with the bran fractions with different particle size were named T1 (larger particles size bran fraction), T2 (intermediate particle size bran fraction) and T3 (smaller particle size bran fraction), respectively. Bread loaves were produced using the formulations reported in Table 2. Wheat flour was partially replaced with the bran fractions to obtain a total fibre content of 6.5% (g fibre/100 g product) in the final products. The water added to the formulations was adjusted by measuring the dough consistency with a Brabender Farinograph to obtain 500 BU (Brabender Units).

Bread loaves were produced with a home bread-maker (Severin BM3986, Germany) using a “wholemeal” program (first kneading, 43 min; second kneading 56 min; first fermentation, 45 min; smoothing 1 min; second fermentation, 18 min; smoothing 1 min; third fermentation, 35 min; baking, 55 min). Bread loaves were cooled to room temperature for 2 h and then analysed. Three bread loaves were produced in three different days for each formulation.

Table 2
Bread formulations.

Ingredient (flour basis)	STD	C1	C2	C3	T1	T2	T3
Wheat flour	100.0	87.0	83.0	76.5	84.0	84.0	84.0
Bran fraction	/	13.0	17.0	23.5	16.0	16.0	16.0
Sugar	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Salt	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Yeast	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Water	55.2	59.8	59.2	61.2	63.1	62.5	63.3
Sunflower seeds oil	3.0	3.0	3.0	3.0	3.0	3.0	3.0

2.3. Bread characterization

2.3.1. Loaf volume, crumb grain and colour

Volume of bread loaves was measured following the American Association Cereal Chemistry 10-05 method (Guidelines for Measurement of Volume by Rapeseed Displacement). Two volume measurements were carried out for each sample.

Crumb grain was studied by means of a digital image analysis system (Image Pro Plus software, Media Cybernetics, Bethesda, USA) as previously described (Chiavaro et al., 2008). Images of the three central slices (20 mm thickness) from each loaf were captured with a Scanjet 8200 HP scanner (Cupertino, USA, 600 dpi resolution). The total number of pores (expressed as percentage) was measured in five preselected areal dimensional classes: class 1: $9 * 10^{-5}$–$2 * 10^{-4}$ mm^2; class 2: $2 * 10^{-4}$–$5 * 10^{-4}$ mm^2; class 3: $5 * 10^{-4}$–$1 * 10^{-3}$ mm^2; class 4: $1 * 10^{-3}$ mm^2 – $1 * 10^{-2}$ mm^2; class 5: $1 * 10^{-2}$ mm^2 – $5 * 10^{-1}$ mm^2.

Colour determination was carried out on bread crust using a Minolta Colorimeter (CM 2600 d, Minolta Co., Osaka, Japan). The spectral curves were determined over the 400–700 nm range using illuminant D65 and with a 2° standard observer. L* (lightness), a* (redness), b* (yellowness) values were measured (CIE Commission, 1978) to calculate the colour difference (ΔE) from STD using the following the equation:

$$\Delta E = \sqrt{\left[\left(L^*_{sample} - L^*_{STD}\right)^2 + \left(a^*_{sample} - a^*_{STD}\right)^2 + \left(b^*_{sample} - b^*_{STD}\right)^2\right]}$$

2.3.2. Texture

Bread crumb hardness was measured using a TA.TX2 Texture Analyzer (Stable Micro Systems, Goldalming – UK). At least six cubic portions ($2 \times 2 \times 2$ cm^3) of crumb were extracted from the central slices of bread loaves and compressed (force = 0.1 N) to 40% deformation using a cylindrical probe (P/35 Dia Cylinder Aluminium). Hardness was taken as the maximum height of the compression peak.

2.3.3. Water status

- *Water activity and moisture content*

Water activity of bread crumb and crust was measured at 25 °C with an Aqualab 4 TE (Decagon Devices, Inc. WA, USA).

Moisture content of crust and crumb (from loaf centre) were determined by weight loss by drying in a forced-air oven (ISCO NSV 9035, ISCO, Milan, Italy) at 105 °C to constant weight.

Table 1
Composition and particle size of bran fractions used for the production of bread samples.

	Composition (%)						Particle size (%)						
	Proteins (%dm)	Moisture (%)	Ashes (%dm)	TDF (%dm)	Fat (%dm)	Starch (%dm)	>1000 (μm)	1000-850 (μm)	800-500 (μm)	500-425 (μm)	425-300 (μm)	300-180 (μm)	<180 (μm)
C1	9.9	11.6	5.7	63.0	5	21.1							
C2	15.0	11.7	6.2	49.0	5.5	29.7	0	0	0	8.0 ± 1.9	28.7 ± 2.4	36.2 ± 2.8	26.9 ± 2.0
C3	18.6	12.0	6.5	36.0	6.3	38.9							
T1		12.7					4.2	26.0	67.7	2.1	0	0	0
T2	13.7	9.8	5.8	52.0	5.3	28.5	0	0	13.4	40.5	18.0	16.0	12.1
T3		8.1					0	0	0	21.6	30.6	27.0	20.8

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