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The impact of pearling as a treatment prior to wheat roller milling on the texture and structure of bran-rich breakfast flakes

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ABSTRACT

While wheat bran has an interesting nutritional profile, its inclusion in food recipes can lead to poor structure and sensory quality of the final product. Here, we studied how outer bran layers affect textural and structural properties of breakfast cereal flakes (containing 20 or 40% regular, aleurone-enriched or reconstituted bran). Aleurone-enriched bran was obtained by removing the outer bran layers by pearling and thereby enriching the bran obtained by subsequent roller milling in aleurone tissue while reconstituted bran was obtained by reconstituting aleurone-enriched bran with pearlings. Flakes containing aleurone-enriched bran were more crispy and maintained better hardness during soaking in milk, especially for 40% bran-rich breakfast flakes, than their regular bran containing counterparts. Inclusion of 40% reconstituted bran in the recipe deteriorated the texture and microstructure. The present work demonstrates that pearling offers bran material that is very suitable as ingredient for producing breakfast flakes with improved textural properties.

1. Introduction

Wheat (*Triticum aestivum* L.) bran is a multi-layered tissue which is separated by milling from the starchy endosperm (flour). From the outside to the inside, miller's wheat bran consists of pericarp, the seed coat, the nucellar epidermis, the aleurone layer and some starchy endosperm. Dietary fiber (arabinoxylan (AX), cellulose, lignin and β-glucan) makes up about 50–55% of the bran. Besides dietary fiber, starch (20%), protein (18%), ash material (5%), and lipids (3–5%) are present (Delcour & Hoseney, 2010; Maes & Delcour, 2001). Sufficient intake of dietary fiber and antioxidants from wheat bran can reduce the risks of cancer, cardiovascular diseases and type II diabetes (Anderson, Smith, & Gustafson, 1994; de Munter, Hu, Spiegelman, Franz, & van Dam, 2007; Schatzkin, Park, Leitzmann, Hollenbeck, & Cross, 2008). Furthermore, wheat bran consumption improves stool bulk and decreases gut transit time. Both effects are at the basis of health claims allowed by the European Food Safety Authority (EFSA, 2010).

The inclusion of bran in food recipes is limited due to adverse effects on the structure, organoleptic profile and shelf life of the resultant products, like breakfast cereals enriched in wheat bran (Chassagne-Berces et al., 2011; Kamaljit, Amarjeet, & Pal, 2011; Rzedzicki & Blaszczak, 2005).

In general, different effects are held responsible for wheat bran's negative effect on product quality. These include water binding, or, in the case of bread making, the impediment of gluten network formation during mixing, decreased gas cell stabilization during fermentation, and enzymatic action. Bran functionality can be (partly) overcome by treating wheat bran to reduce enzyme activities and particle size distribution and to change tissue composition (Dornez, Cuyvers, Gebruers, Delcour, & Courtin, 2008; Gan, Galliard, Ellis, Angold, & Vaughan, 1992; Zhang & Moore, 1999). Gan et al. (1992) and Blandino et al. (2013) reported that the outer wheat bran layers are the most deleterious for bread quality. As a wheat processing pre-treatment, pearling removes the outer layers of wheat kernels by abrasion to a predetermined degree. Durum wheat (*Triticum turgidum* L. ssp. *durum*) is frequently pearled. Besides an increased semolina yield, semolina from pearled wheat produces less brown and brighter spaghetti without affecting the cooked spaghetti texture (Dexter et al., 1994). For common wheat, pearling prior to roller milling is rare, but is expected to also yield raw materials with improved quality (Gys, Gebruers, Sorensen, Courtin, & Delcour, 2004; Mousia, Edherly, Pandiella, & Webb, 2004).

We here examined whether removal of wheat outer bran layers by pearling offers perspectives for producing aleurone-enriched bran for manufacturing bran-rich breakfast flakes with improved

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texture. Regular bran, aleurone-enriched bran and reconstituted bran material, obtained by reconstituting aleurone-enriched bran with pearlings, were incorporated in a breakfast flake recipe containing 20 or 40% bran. The textural and structural properties of the resultant flakes were studied.

2. Materials and methods

2.1. Materials

Wheat was supplied by Alco Bio Fuel (Ghent, Belgium) and pearled to two different degrees by removing 4.2 and 6.0% of the kernel weight by Satake (Bredbury, UK). The pearlings were obtained as a fine powder (mean particle size of about 200 μm). The breakage of wheat kernels during processing, determined by sieving the pearled kernels over a 2.38 mm sieve, was 4.3% (±0.2%) and 3.8% (±0.4%) upon removing 4.2% and 6.0% material, respectively. Both non-pearled and pearled wheat kernels were conditioned to 15.0% moisture in 24 h (Mousia et al., 2004) and subsequently milled with a Bühler MLU-202 laboratory scale mill (Uzwil, Switzerland) using the milling diagram described in Delcour, Vanhamel, and De Geest (1989). Milling of non-pearled and pearled wheat kernels yielded regular and aleurone-enriched bran, respectively. The other milling fractions included shorts as well as three break and three reduction flour fractions. Pearlings and aleurone-enriched bran were mixed in a ratio corresponding to their respective milling yields to form reconstituted bran.

Commercial rice, wheat and malt flour, salt, sucrose, glucose and whey powder were supplied by the Institut für Getreideverarbeitung (IGV, Potsdam, Germany).

All chemicals were from Sigma–Aldrich (Bornem, Belgium) and of at least analytical grade.

2.2. Standard analyses

Moisture and ash contents of the bran materials were measured according to AACC Methods 44-15A and 08-12 (1999), respectively. Protein content was determined using an adaptation of the AOAC Official Method 990.03 (1995) to an automated Dumas protein analysis system (EAS, VarioMax N/CN, Elt, Gouda, The Netherlands) using 6.25 as nitrogen to protein conversion factor. Dietary fiber contents were analyzed according to AOAC Official Method 991.43 (1995). Total non-cellulosic carbohydrates were estimated by gas chromatography of alditol acetates after acid hydrolysis, reduction and acetylation of the resulting monosaccharides as in Courtin, Van den Broeck, and Delcour (2000). AX content was calculated as 0.88 times the sum of xylose and arabinose contents and starch content as 0.90 times glucose content. Moisture content of the bran-rich breakfast flakes was determined using a Sartorius Moisture Analyzer MA30 (Göttingen, Germany). All analyses were done at least in triplicate.

2.3. Production of breakfast flakes

Breakfast flakes were produced on pilot scale (~1.5 kg) essentially as in Joye, Lamberts, Brijs, and Delcour (2011) but with small adaptations. The levels of wheat bran materials used were 20 g/100 g and 40 g/100 g and are further referred to as 20% and 40% bran-rich breakfast flakes respectively. 100 g mixture of 20% bran-rich breakfast flakes contains 31.5 g wheat flour, 32.0 g rice flour, 3.0 g malt flour, 20.0 g wheat bran, 3.0 g whey powder, 0.5 g salt, 7.5 g sucrose and 2.5 g glucose while for 40% bran-rich breakfast flakes 10.0 g wheat flour and 10.0 g rice flour were replaced by wheat bran. Wheat bran materials used were regular bran, aleurone-enriched bran (4%), aleurone-enriched bran (6%), reconstituted bran (4%) and reconstituted bran (6%), with (4%) or (6%) pointing to the degree of pearling (4.2% or 6.0%). First, the ingredients were blended dry for 2 min in a Stephan UMS 5 electronic mixer (Hameln, Germany). Then, water was added to a final moisture content of 28 g H_2O/100 g. Mixing continued for 2 min with the same device, after which dough was mixed by hand and then again for 30 s in the mixer to ensure proper homogenization. After a 30 min rest, the mixture was extruded with a Brabender (Duisburg, Germany) single screw extruder (103 °C, 700 kPa) to form pellets. The moisture level of the extruded pellets was approximately 25 g H_2O/100 g. They were then flaked at room temperature with a roller mill (Schule, Hamburg, Germany) with a roll gap setting of 0.25 mm and dried in a climate chamber HC0057 (Heraeus Vötsch, Hanau, Germany) for 2 h at 40 °C and 35% relative humidity until a moisture content of 15 g H_2O/100 g. Finally, the flakes were roasted in an electrically heated Küppersbusch combination cooker convect-air CEC 106 (Gelsenkirchen, Germany). The 20% and 40% bran-rich breakfast flakes were roasted at 190 °C for 3 and 2 min, respectively, to obtain a moisture level of about 2–3 g H_2O/100 g. When roasting to too low moisture level (about 1 g H_2O/100 g), the resultant products were darker and had a burnt odor.

Bulk density of the flakes was determined in sixfold by filling a graduated cylinder of 2.0 L (diameter 92 mm) to a fixed volume and weighing. The thickness of the flakes was measured with a digital caliper on 10 different flakes. The coefficients of variation did not exceed 5% for bulk density and 15% for flake thickness readings.

2.4. Instrumental texture analysis

The texture of the flakes was studied before and after soaking using an Instron (Norwood, MA, USA) material testing machine equipped with a 1 kN load cell. Tests were conducted in bulk with a five-blade Kramer shear cell. Breakfast flakes (15.0 g) were evenly spread over the bottom of the cell. In the test, the Kramer shear cell blades forced the bran-rich breakfast flakes through the open spaces at the bottom of the cell. Samples were compressed and extruded at 120 mm/min at 22 ± 1 °C. The maximum force (F_{max}) was taken as a measure for the hardness of the samples. The spatial frequency of ruptures (N_{sr}), the average crushing force (F_{cr}) and crispness work (W_c) were calculated from the force-deformation curves with formulas (1), (2) and (3) respectively with S the area under the curve, n the number of peaks and d the probe travel distance (Agbisit, Alavi, Cheng, Herald, & Trater, 2007):

$$N_{sr} = \frac{n}{d}\left(\mathrm{mm}^{-1}\right) \quad (1)$$

$$F_{\mathrm{cr}} = \frac{s}{d}(N) \quad (2)$$

$$W_c = \frac{F_{\mathrm{cr}}}{N_{\mathrm{sr}}}(N\ \mathrm{mm}) \quad (3)$$

Samples were analyzed in tenfold. Coefficients of variation of F_{max}, N_{sr}, F_{cr} and W_c did not exceed 10%.

2.5. Soaking process of breakfast flakes

Approximately 15.0 g accurately weighed breakfast flakes were placed in a tea strainer and soaked in 500 ml of semi-skimmed milk at 22 ± 1 °C during 30, 120 or 240 s under continuous stirring (200 rpm) (Sacchetti, Pittia, Biserni, Pinnavaia, & Rosa, 2003). After soaking, bran-rich breakfast flakes were drained for 30 s to remove