Journal of Cereal Science 64 (2015) 1–10

Contents lists available at ScienceDirect

Journal of Cereal Science

journal homepage: www.elsevier.com/locate/jcs

Wet grinding and microfluidization of wheat bran preparations: Improvement of dispersion stability by structural disintegration

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ARTICLE INFO

Article history:
Received 18 August 2014
Received in revised form
25 February 2015
Accepted 3 April 2015
Available online 5 May 2015

Keywords:
Sedimentation
Wet grinding
Microfluidization
Dispersion stability

ABSTRACT

The enrichment of liquid food matrix with wheat bran has not yet been explored. This study investigated the impact of disintegrating wheat bran preparations on their stability at high moisture content. Three wheat bran preparations – standard bran, peeled bran and aleurone rich fraction – were modified by dry grinding, enzymatic degradation, wet grinding and microfluidization. The sedimentation of processed preparations was evaluated in water solution and related to their physical structure, solubilized compounds and suspension viscosity. In dry ground preparations mixed in water (5% w/w), most of the particles sedimented already in 5 min. Wet grinding disintegrated the physical structure of bran preparations (d_{50} = 10–16 μm), causing improvement of particle stability due to reduction of gravitational sedimentation. Enzymatic treatment with xylanase efficiently increased the total solubility of the bran preparations (from 18–24% to 40–50%), but the higher solubility was not related to the better stability of particles. Microfluidization of peeled bran and aleurone increased the viscosity and stability of dispersions. The higher viscosity of the microfluidized dispersions was likely correlated with the better homogenisation of the particles, and also with the modified microstructure of treated bran preparations. Disintegrated wheat bran preparations showed high potential for beverage applications.

1. Introduction

Wheat bran is a low price ingredient obtained during the milling process by separation of the outermost layers of wheat kernel from the inner part (i.e. starchy endosperm). Annually, millions of tons of wheat bran result as a by-product of the milling industry and it is mainly used as animal feed. However, the use of wheat bran for food applications has raised interest due to its great nutritional potential. Wheat bran is rich in dietary fibre (especially arabinoxylans, β-glucan, cellulose and lignin), proteins and many bioactive compounds such as antioxidants and vitamins. The consumption of wheat bran in a ready-to-eat breakfast cereal lowered food intake in healthy men (Freeland et al., 2009) and it also increased the satiety and feelings of fullness when present in beverages (Lyly et al., 2009). In addition, the European Food Safety Authority has approved two different health claims related to the gut health. The first claim states that "wheat bran fibre contributes to an increase in faecal bulk", and in order to justify the claim, a food should be at least "high in fibre". The second health claim stated that "wheat bran fibre contributes to a reduction in intestinal transit time". In order to obtain the claimed effect at least 10 g per day of wheat bran fibre should be consumed in one or more servings.

Addition of wheat bran in food systems may confer difficulties especially during processing and in terms of sensory acceptance by consumers. The technological effects of wheat bran addition in solid foods have been studied mainly in cereal-based products such as bread, extruded snacks, noodles, pastas, muffins and cookies (Foschia et al., 2013). In beverages, wheat bran could be used as an additive in order to increase the amount of dietary fibre and other bioactive compounds. Fibre derived from oats has been studied for potential use in beverages (Sibakov et al., 2013), but there is no up-to-date data related to the technological or sensory effects of whole wheat bran in beverages. The particle properties of wheat bran have limited its use in beverage applications. Challenges of introducing wheat bran in beverages include the prevention of phase separation (stabilization of the particles in solution) and counter-balancing the bitter taste.

Wheat bran is composed of a complex cellular matrix and it is very difficult to degrade. Many techniques have been studied to

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http://dx.doi.org/10.1016/j.jcs.2015.04.002
0733-5210/

improve its applicability in food products, such as debranning, fractionation, extrusion, fermentation and enzymatic treatments (Coda et al., 2014; Katina et al., 2012). Debranning (i.e. pearling or peeling) removes a part of the outer layers, especially outer pericarp, and it can be used for producing potential ingredients due to the reduction of microbial contamination (Blandino et al., 2013). Dry fractionation of wheat bran can be used for producing fractions enriched in aleurone cells, rich in DF and bioactive compounds of wheat with smaller impact on the quality of the final cereal products (Brouns et al., 2012). For the development of beverages enriched with wheat bran, particle size reduction and disintegration of cellular matrix might be necessary for better dispersion stability. Dry grinding was shown to be an efficient tool to reduce wheat bran particle size, increasing its surface area and also its nutritional properties (Hemery et al., 2010; Rosa et al., 2013), but wet grinding could be a promising technique which has not yet been applied for wheat bran. Enzymatic treatments on wheat bran disintegrated its structure in low (40%) or high (90%) moisture conditions (Santala et al., 2011) and have been shown to improve its performance in baking applications (Katina et al., 2006). Microfluidization was also recently shown to be efficient in reducing wheat bran particle size (Wang et al., 2012). In this technique, the sample under high pressure is forced through an auxiliary processing module and an interaction chamber made out of small channels, resulting in high stream velocities and shear forces as the sample collides with itself and the channel walls (Chen et al., 2013).

The focus of this study was to investigate how the structure and composition of wheat bran preparations affect their stability in high-moisture conditions. With this aim, three wheat bran preparations with progressive degree of outer layers were used: standard bran, peeled bran (4% of the outer layers removed) and aleurone (wheat fraction enriched in aleurone cells). The structure of these three preparations was modified by combining enzymatic degradation, wet grinding and microfluidization. The stability of processed preparations in water was evaluated and related to their physical structure parameters, soluble compounds and viscosity.

2. Materials and methods

2.1. Raw materials and chemical characterization

Coarse standard and peeled brans were provided by Kinnusen Mylly (Utajärvi, Finland). For the peeled bran, the grains have been peeled to remove around 4% of the outer layers and then milled to separate the bran. The material rich in aleurone (Vein of gold® wheat aleurone) was provided by Kampffmeyer Food Innovation GmbH (Hamburg, Germany). The methods used for the characterisation of the wheat bran preparations were: total protein content by the American Association of Cereal Chemists (AACC) method no. 46–11A, total dietary fibre by AOAC method no. 985.29, fat by AOAC method no. 922.06, digestible starch by the Megazyme kit, and ash gravimetrically by burning at 550 °C. The moisture content of the samples was determined by oven drying (1 h at 130 °C). For the quantification of total pentosan, 0.1 g of sample was mixed with 5 ml of 0.5 M H_2SO_4 and boiled for 20 min and centrifuged, followed by the colourimetric determination (Douglas, 1981).

2.2. Processing

Four kinds of processing, single or combined, were carried out: dry grinding, enzymatic treatment (ET), wet grinding (W) and microfluidization (M). The experimental design of the study is described in Fig. 1.

2.2.1. Dry grinding

The coarse and peeled wheat brans were ground by passing two times through an impact mill 100 UPZ (Hosokawa Alpine, Germany; screen size 0.3 mm). The aleurone already had a very fine particle size, so it was not ground further.

2.2.2. Enzymatic treatment

A commercial *Bacillus subtilis* xylanase preparation Depol 761P (Biocatalysts Ltd, Cardiff, UK) was used at a level of 200 nkat xylanase/g bran or aleurone. The enzyme powder was mixed with the preparations and distilled water was added to reach 25% dry

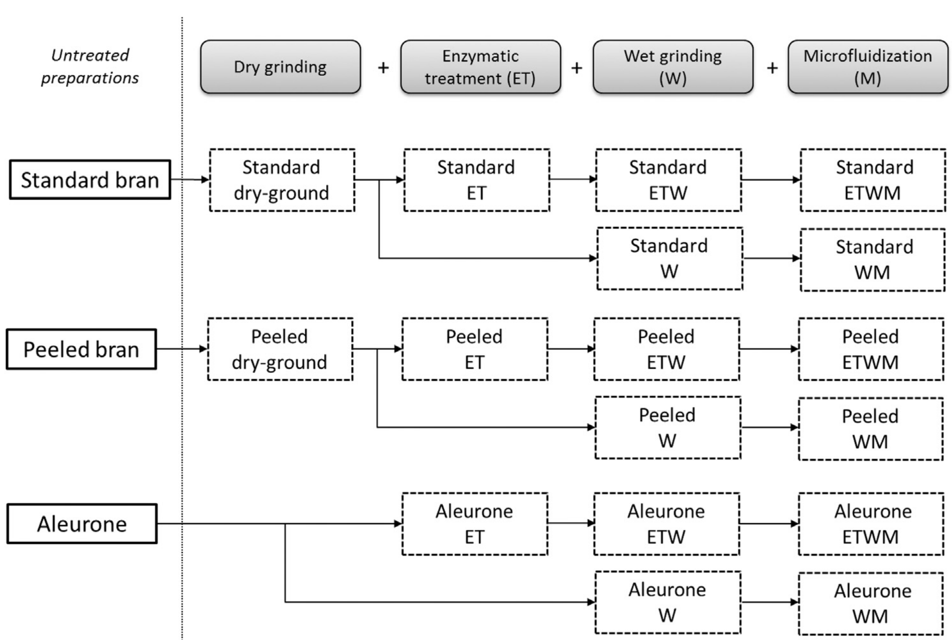

Fig. 1. Experimental design consisting of dry grinding, enzymatic treatment (ET), wet grinding (W) and microfluidization (M) steps.