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Antioxidant activity and dietary fibre in durum wheat bran by-products

Fabrizio Esposito [a], Guido Arlotti [b], Angela Maria Bonifati [b], Aurora Napolitano [a], Davide Vitale [c], Vincenzo Fogliano [a,*]

[a] *Dipartimento di Scienza degli Alimenti, Università di Napoli "Federico II" Parco Gussone-Ed.84, Portici, NA 80055, Italy*
[b] *Barilla Alimentare S.p.A., Via Mantova 166, Parma, Italy*
[c] *Rizzolio e C. Alimentazione, Via Valle S. Giovanni, 31 – 14049 Nizza Monferrato (AT), Italy*

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Abstract

Milling of wheat generates by-products, which can be used to improve the technological performance and/or to integrate foods with healthy compounds. The aim of this paper was to select fractions of durum wheat bran having different functional and nutritional characteristics. Wheat bran by-products were obtained by an industrial milling process. Beside the single fractions, two commercial products Bran & Brain 50 and 70, obtained by blending some of the durum wheat fractions were also studied. All samples were investigated for water holding capacity, soluble and insoluble dietary fibre content and for their antioxidant activity. The soluble fibre content of the durum wheat by-product ranged between 0.9% and 4.1%; while that of insoluble fibre between 21% and 64%. B&B 70 has a TDF content of 61%, while B&B 50 has 42%. The water holding capacity of each fraction is strictly related to the amount of insoluble fibre and to the granulometry of the by-products. Cooking-extrusion process does not affect the amount of soluble fibre; by contrast, a significant increase of the insoluble fibre was detected. The antioxidant activity is higher for the internal bran fraction and it increases in fractions having reduced granulometry. The antioxidant activity of some durum wheat by-product fractions is comparable to that of widespread fruits and fresh vegetables, likely due to the presence of fibre-bound phenol compounds. The high fibre content and antioxidant activity of durum wheat bran by-products can be of particular interest for their use in cereal-based products.

Keywords: Durum wheat; Pre-processed fraction; Fibre; Extrusion-cooking; Antioxidant activity phenol compounds

1. Introduction

Wheat by-products have unique functional and nutritional properties related to colour and cooking performance and to their content of dietary fibre (Dexter et al., 1994a, Dexter, Symons, & Martin, 1994b).

Dietary fibre (DF) includes cellulose and lignin, hemicellulose, pectins, gums and other polysaccharides and oligosaccharides associated to plant. It is actually defined as "edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine" (Mongeau, 2003). It is conventionally classified in two categories according to their water solubility: IDF, insoluble dietary fibre (cellulose, part of hemicellulose and lignin) and SDF, soluble dietary fibre (pentosans, pectins, gums, mucilage).

The main physiological effect of insoluble fibre is the improvement of gut peristalsis, which is connected to the

Abbreviations: DF, dietary fibre; TDF, total dietary fibre; IDF, insoluble dietary fibre; SDF, soluble dietary fibre.

* Corresponding author. Tel.: +39 81 2539356/7752744; fax +39 81 7754942/62580.
E-mail address: fogliano@unina.it (V. Fogliano).

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water holding capacity (WHC) and to the effect on viscosity (Schneeman, 1999). On the other hand soluble fibre has multiple functions. It represents a good substrate for some lactic bacteria and Bifidobacteria strains, which are beneficial for gut health (prebiotic action) (Grizard & Barthomeuf, 1999), it is able to control glycemic index (Tudorica, Kuri, & Brennan, 2002), and it reduces plasmatic cholesterol (Brown, Rosner, Willett, & Sacks, 1999). The mechanisms that account for these actions are only partially elucidated, however, the inverse correlation between the intake of soluble fibre (contained in cereals, legumes, fruits and vegetables) and the risk of cardiovascular disease and cancer is firmly established and it led to two health claims of the Food and Drug Agency.

Up to now wheat milling by-products are mainly used in "all-bran" breakfast extruded products (Eastman, Orthoefer, & Solorio, 2001). These products contain almost exclusively IDF (the average amount of SDF is about 1.5%) while many recent nutritional studies stressed that the average dietary intake of SDF is far below the optimum (Cui, Wood, Weisz, & Beer, 1999). Milling process can be modulated to get cereal by-products enriched in fibre and also with a decreased ratio between insoluble and soluble fibre (Dexter & Wood, 1996). The recently developed technological advances in the processing of durum wheat allow separating different fractions indicated as durum wheat by-products. Some of these products mainly containing IDF can be used to hold free water, while others, containing high amount of SDF, are of great nutritional value (Dexter & Wood, 1996). Approaches other than milling modulation were attempted to obtain SDF-enriched fractions from cereals. In some studies enzymatic modification of raw material was carried out (Ingelbrecht, Moers, Abecassis, Rouau, & Delcour, 2001; Quaglia & Carletti, 1995). Other authors were able to achieve similar results during processing by an appropriate modulation of extrusion-cooking parameters (Ning, Villota, & Artz, 1991; Wang, Klopfenstein, & Ponte, 1993).

Chemical classification of the fibre present in the different fractions obtained by durum wheat milling process could be of interest in order to address the choice among their possible applications as food ingredients (Feillet, Abecassis, & Laignelet, 1996). Functional and nutritional properties of the fibre can be used to drive this selection, taking into account, beside the IDF/SDF ratio, also the antioxidant activity of these materials. There are several studies showing the marked antioxidant activity of cereal products (Andlauer & Furst, 1998; Borrelli, Esposito, Napolitano, Ritieni, & Fogliano, 2004; Miller, Rigelhof, Marquart, Prakash, & Kanter, 2000). This activity is mainly due to phenol compounds that can be either the same contained in fruits and vegetables, or unique of the specific cereal (Adom, Sorrells, & Liu, 2003; Ho, 1992). Whole grain bread had an antioxidant activity, which is almost double than that of white bread (Miller et al., 2000) and can act as free radical scavengers through the entire digestive tract and in colon tissue. It is clear that antioxidant are concentrated in the bran fraction, however, it is not clear at which extent both free and carbohydrate-bound compound are measured by a given assay (Zhou, Laux, & Yu, 2004). This finding indicates the fundamental contribution of bran and germ to the whole cereal antioxidant activity and it is explained by the fact that phenol compounds are associated with the outer layers, particularly the aleurone layer (McKeehen, Busch, & Fulcher, 1999; Mueller-Harvey, Hartley, Harris, & Curzon, 1986; Regnier & Macheix, 1996). Despite this evidence this parameter was scarcely considered in the characterisation and differentiation of durum wheat by-products, although it is conceivable that the antioxidant compounds present in the pericarp and aleurone layers are recovered in the by-product fractions (Dexter & Wood, 1996; Martianez-Tomea et al., 2004).

The aim of this paper was to select fractions of durum wheat bran having different functional and nutritional properties. Wheat bran by-products were obtained by an industrial milling process. Beside the single fractions, two commercial products Bran & Brain 50 (B&B 50) and Bran and Brain 70 (B&B 70), produced by blending some of the durum wheat by-products were also considered, in order to compare their properties with those of single fraction. In particular, the obtained fractions have been characterised evaluating the water holding capacity, the nature of fibre (SDS/IDF ratio) and the antioxidant activity. Results of experiments aimed at increasing the soluble/insoluble fibre ratio using the extrusion-cooking technology will be also reported.

2. Materials and methods

2.1. Samples

Three fractions indicated as fraction A, B and C, respectively, have been obtained by successive abrasions of durum wheat kernel. Fraction A corresponds to the external layers of the wheat kernel, fraction B to the intermediate layers, and fraction C to the internal layer close to the aleurone. Fractions A, B and C were further sub-fractionated using decreasing mesh sieves from 500 to 180 μm. These fractions were further treated by mashing and air through, obtaining two commercial products indicated as B&B 70 e B&B 50. The proximal characteristic of these products are as follow. B&B 70: water 5%, ash, 4%, lipids, 3%, proteins, 8%. B&B 50: water 5%, ash, 6%, lipids, 5%, proteins, 11%.

2.2. Extrusion-cooking treatment

The experiments were performed using a pilot cooking-extrusion plant model BC21, (Clextral). Experiments