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Hull-less barley pearling fractions: Nutritional properties and their effect on the functional and technological quality in bread-making

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ABSTRACT

Breads enriched with hull-less barley (HLB) have been characterized. An HLB cultivar was sequentially pearled, and the fractions were analysed for their bioactive components. Ash, proteins, dietary fibre (DF) and total antioxidant activity (TAA) decreased from the external to the internal layers, while β-glucans showed an inverse trend.

Two functional ingredients were selected: an external fraction (5–15% w/w) and a debranned inner fraction (25–100%). Five mixtures of refined commercial flour, with increasing replacement with pearled HLB fractions, were used for each ingredient to prepare bread.

The addition of the external layers led to a higher enrichment in ash, proteins, DF and TAA, and showed significant changes in the rheological parameters, with detrimental effects on the bread volume and texture. At a 10%-substitution level, the technological properties were acceptable and similar to those shown by the control, while the nutritional value was significantly improved. Conversely, the addition of the inner kernel fraction was also successfully employed at high replacement levels, with only a few physical and rheological changes. This ingredient led to a lowering of the improvement in the antioxidant compounds, but it clearly enhanced the DF and β-glucan contents in the bakery products.

1. Introduction

Consumer awareness about high-fibre diets and food naturally rich in components with health-promoting effects is increasing (Siró et al., 2008). Thus, there is a great interest in improving the nutritional profile of white wheat baked goods through supplementation with flour or bran of different origins. In a multigrain approach, the use of other cereals is a recent trend in the baking industry to obtain multiple functional benefits in bakery products (Bartlomiej et al., 2012). Among the different cereals, barley has been studied in particular as a source of dietary fibre (DF), especially because of its high natural β-glucan content, non-starch unbranched polysaccharides, composed of (1 → 4) and (1 → 3) linked β-D-glucopyranosyl units. In addition, barley is an important source of other bioactive compounds, that show marked antioxidant activity (Liu and Yao, 2007).

Of the various barley cultivars, hull-less barley (HLB) has recently been receiving considerable research attention concerning the development of functional food, as it is an excellent source of both soluble and insoluble fibre. Hull-less (or "naked") barley (*Hordeum vulgare* L. var. *nudum* Hook. f.) is a form of domesticated barley, in which, unlike hulled barleys but similarly to wheat, the lemma and palea (hull) are non-adherent to the caryopsis. The total β-glucan content of HLB is higher than that of hulled barley genotypes, whereas the insoluble DF content is lower (Xue et al., 1997).

The development of functional bakery products could offer an excellent opportunity to introduce several new uses of barley. Furthermore, it is crucial to obtain ingredients that can be incorporated into regular food at physiologically effective levels, without compromising the technological quality of the bakery products (Poutanen et al., 2014). The addition of DF to baking products, through cereal bran or other by-products, generally leads to a

Abbreviations: DDT, dough development time; DF, dietary fibre; DON, deoxynivalenol; dw, dry weight; HLB, hull-less barley; TPC, total phenolic compounds; TAA, total antioxidant activity; TE, trolox equivalents; TPA, texture profile analysis.

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reduction in loaf volume, changes in crust colour and a denser crumb texture, and therefore represents a technological drawback. These effects are particularly evident when barley grain flour or barley fractions are used (Ragaee et al., 2011), and represent a drawback to the increasing consumption of whole-grain products, since consumers generally prefer white bread.

Cereal grain fractionation technologies have been proposed as a way of obtaining new ingredients from raw grain materials, with technologically optimized functional and nutritional attributes (Liu et al., 2009). Among the different fractionation processes, sequential pearling, which involves an abrasive scouring process that gradually removes kernel layers, has provided interesting results for the development of new products.

Hulled barley is generally pearled in order to discard the hull and bran fractions and to obtain pot and pearled barley, which represents ≈60–70% of the total grain weight (Jadhav et al., 1998). Because of its anatomical structure, the application of pearling to HLB is not necessary; however, this process could be an interesting way of providing grain fractions with unique compositions, which could be useful for the development of consumer-friendly bakery products. In fact, the pearling degree could be modulated to separate different grain fractions, with different health benefits or detrimental effects on the technological quality and on safety (Sovrani et al., 2012).

The aims of this study were: i) to quantitatively fingerprint the bioactive compounds of HLB kernel fractions, while evaluating the detrimental factors, through a sequential pearling process, in order to design new functional ingredients; ii) to evaluate the nutritional enhancement and the technological impact connected to the incorporation (at several replacement levels) of differently pearled HLB fractions into bread.

2. Materials and methods

2.1. Sequential barley grain pearling

A grain lot of HLB (cultivar Mona: a two-row, spring, regular starch variety) was purchased from Società Italiana Sementi (San Lazzaro di Savena, BO, Italy).

Six fractions of kernels were obtained through incremental pearling, according to the approach described in Sovrani et al. (2012). The pearling consisted of consecutive passages of barley grain in an abrasive-type grain testing mill (TM-05C model, Satake, Tokyo, Japan). Starting from unprocessed grain, the kernels were initially pearled to remove 5% of the original grain weight, and this resulted in a first fraction (0–5% w/w). The remaining kernels were then pearled to remove a second fraction of 5% (5–10% w/w). The pearling process was continued until other 3 fractions (designed 10–15%, 15–20%, 20–25%, respectively) plus a residual 75% of the kernel (25–100% w/w), were collected.

The whole grain samples and the residual 75% of the unprocessed kernels were milled using a laboratory centrifugal mill (ZM-100; Retsch, Haan, Germany) with a 1 mm opening. Then, both the milled and pearled samples were ground to pass through a 0.5 mm screen and stored at −25 °C until the chemical analyses.

2.2. Substitution of flour with barley pearled fractions in the bread making procedure

On the basis of the results obtained through the sequential pearling of the HLB kernels, two different fractions (external layer and debranned inner kernel) were prepared and used to obtain functional flour for bread-making. Starting from unprocessed grain, the barley kernels were initially pearled to remove 5% of the original grain weight, and this most external fraction was discarded. The remaining kernels were then pearled to remove a second 10% fraction of the original grain weight (5–15%), and this fraction was used as a first “functional ingredient” (external layer). The remaining kernels were further pearled until 25% of the original grain weight was removed (this fraction was discarded); the residual pearled grain (25–100%) was ground to pass through a 0.5 mm screen, and used as a second “functional ingredient” (debranned inner kernel).

The two selected fractions were used to replace conventional refined wheat flour for bread-making, at different percentages. The particle size of the selected pearling fractions was similar to that of refined commercial flour; in both cases, more than 80% of the particles fell within the <200 μm size range.

Five mixtures of refined bread-making commercial flour with increasing pearled barley fraction replacement rates (5%, 10%, 15%, 20%, 25%) were made from the two pearling fractions selected as functional ingredient, used for bread making, and compared with a control with no wheat flour replacement. The refined flour and the selected pearled barley fractions were accurately mixed using a rotary laboratory blender (Beccaria S.r.l., Cuneo, Italy). The Chopin® alveograph parameters of the used commercial refined flour were: deformation energy (W) 325 J 10^{-4} and curve configuration ratio (P/L) 0.52.

The bread was prepared according to the method previously described in Blandino et al. (2013). Three composite loaves were prepared for each replacement level and used as replicates for chemical and technological analyses.

2.3. Chemicals

The total Dietary Fibre (DF) and Mixed-Linkage β-Glucan kits for the enzymatic determination were supplied by Megazyme (Megazyme International Ireland Ltd, Wicklow, Ireland). The solvents (HPLC) and formic acid (50%, LC–MS grade) were purchased from Sigma–Aldrich (Milan, Italy). The water was obtained from Milli-Q Instrument (Millipore Corp., Bedford, MA, USA). The antibody-based immunoaffinity columns were supplied by VICAM (Waters Corporation, Watertown, MA, USA). The analytical standards (purity ≥ 95%) and all the other chemicals (reagent-grade level) were purchased from Sigma–Aldrich (Milan, Italy).

2.4. Chemical analyses on the pearling fractions and breads

2.4.1. Sample preparation

The flours and barley pearled fractions were analysed without any pre-treatment.

Bread samples were ground in a laboratory mill (ZM-100; Retsch, Haan, Germany), and in the case of DF, total phenolic content (TPC) and total antioxidant activity (TAA) determinations, they were also freeze-dried (Heto Drywinner 8, Copenhagen, Denmark). The lyophilized samples were ground in an oscillatory mill (Mixer Mill MM440, Retsch GmbH, Hann, Germany). The barley pearled fractions, whole flour and freeze-dried ground bread were sieved (particles size <250 μm) prior to the TAA analyses.

2.4.2. Proximate composition

All the samples were characterized for their moisture, total protein, ash, dietary fibre (total and insoluble) and β-glucan contents. The adopted methods have already been described for the characterization of wheat pearling fractions and derived bread (Blandino et al., 2013; Sovrani et al., 2012). The conversion factors employed to calculate the total protein content were 5.83 and 5.70 for barley and bread, respectively.