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The potential of naked barley sourdough to improve the quality and dietary fibre content of barley enriched wheat bread

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ABSTRACT

The possibility of using naked barley for food products is gaining popularity due to its dietary fibre content, especially β-glucans. The technological process (dough preparation, fermentation and baking) influences bread quality but also may contribute to degradation or preservation of valuable grain components. The aim of the study was to investigate the effects of different wholemeal barley flour share and bread production method on the quality of bread and non-starch polysaccharides content and solubility.

Barley enriched bread contained more both soluble and insoluble dietary fibre and β-glucans, products of 40% barley share contained 67% more total dietary fibre and 160% more β-glucans than control. However, barley incorporation decreased the amount of soluble arabinoxylans. High barley contents contributed to the breads' volume reduction by 14% and change in their crumb and crust colour. However, barley enriched breads gained higher ratings of taste than wheat bread. Barley sourdough fermentation improved breads' volume, colour and sensory properties. Sourdough fermentation also resulted in higher concentration of dietary fibre, arabinoxylans and β-glucans. The beneficial effect of barley addition to wheat bread may be successfully enhanced by using barley wholemeal sourdough fermentation.

1. Introduction

In recent years, improving the nutritional profile of white wheat bread has been of much interest. This is usually accomplished by supplementing wheat flour with a number of flours of different origin that contribute to enhanced mineral, vitamin, protein or dietary fibre composition and content in the final product (Škrbić et al., 2009). Barley (*Hordeum vulgare* L.) is an important crop worldwide. It has become less popular for bakery products due to its poor baking performance and lower sensory quality of the products (Jacobs et al., 2008; Skendi et al., 2010). Nevertheless, barley is gaining increasing attention due to its dietary fibre content and composition (Baik and Ullrich, 2008; Holtekjølen et al., 2008b; Izydorczyk and Dexter, 2008). Numerous studies were taken on the applicability of barley in bread making (Collar and Angioloni, 2014; Holtekjølen et al., 2008b; Izydorczyk et al., 2008; Jacobs et al., 2008; Skendi et al., 2010). Barley genotypes have been classified as hull-less and hulled. Hull-less cultivars have better nutritional value than hulled ones as they contain more proteins, lipids and soluble dietary fibres (Kinner et al., 2011; Škrbic et al., 2009).

Naked (hull-less) barley is a good source of soluble (SDF) and insoluble (IDF) dietary fibre. Dietary fibre contributes to beneficial physiological impact, decreases cholesterol and blood glucose level. It is proved that the high content of dietary fibre in whole grain plays a significant role in the health promoting effect and there is a strong relationship between chronic diseases and obesity and the intake of dietary fibre (Izydorczyk and Dexter, 2008).

The significant parts of the soluble dietary fibre in barley are mixed-linkage (1 → 3), (1 → 4)-β-D-glucans. β-glucans are known for their ability to lower plasma cholesterol, reduce glycemic index, improve lipid metabolism, boost the immune system and reduce the risk of colon cancer. Physiological effect of β-glucans is caused by the ability to form solutions of high viscosity (Dickin et al., 2011; Izydorczyk et al., 2008; Kinner et al., 2011; Rieder et al., 2012; Skendi et al., 2010; Škrbic et al., 2009; Wood, 2007).

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The nutritional value of other non-starch polysaccharides contained in barley-arabinoxylans is also promising (Izydorczyk et al., 2008). It is presumed that they may have similar physiological effects to β-glucans due to their ability to form viscous solutions that slows the rate of digestion in monogastrics. (Izydorczyk and Dexter, 2008). Water soluble arabinoxylans from maize, wheat and rye are demonstrated to have a positive impact on cecal fermentation, production of short-chain fatty acids, reduction of serum cholesterol, and improved adsorption of calcium and magnesium (Izydorczyk and Dexter, 2008). It is also considered that the β-glucans from barley in combination with arabinoxylans may improve the shelf life of bread (Holtekjølen et al., 2008b).

Sourdough fermentation influences both the taste of bread and its nutritional quality. Besides the flavour compounds formation, sourdough fermentation leads to decrease of enzymatic activity and increase of arabinoxylans solubility (Gänzle, 2014). It has been shown that sourdough improved the dough structure and bread quality (volume and form ratio) of breads containing whole grain barley, but showed little effect on the breads prepared with sifted barley flour (Rieder et al., 2012). The positive effect of sourdough on whole grain barley bread may be related to a softening effect on bran particles during fermentation resulting in less mechanical disrupture of the gluten network and gas cells in the dough (Rieder et al., 2012).

Naked barley incorporation to wheat bread and the bread making process have a significant impact on bread quality and cereal nutrients. Beneficial effect of barley addition can be differential depending on the bread production method and the composition of the products may be eligible for changes caused due to subsequent technological processes. Therefore, the aim of the study was to analyze the effects of different naked barley flour share and dough preparation methods on the wheat-barley bread quality and its dietary fibre content and non-starch polysaccharides content and solubility.

2. Experimental

2.1. Materials

Wheat flour type 750 obtained from Good MIlls Poland (Stradunia, Poland) was used for dough formulations. Compressed yeast and commercial freeze-dried Saf Levain LV1 starter cultures (*Saccharomyces chevalieri*, *Lactobacillus casei* and *Lactobacillus brevis*) were supplied by Lesaffre Bio-Corporation Inc. (Łódź, Poland). Spring hull-less barley (*Hordeum vulgare* L) (Gawrosz cultivar) supplied from Plant Breeding Strzelce Ltd. IHAR Group, Poland (cultivation from 2011 year) were used in the study. Wholemeal barley flour of particle size of 0,8 mm was obtained by milling grain in laboratory conditions using Hagberg Perten's Mill (Lab Mill type 120).

2.2. Dough formulations and bread baking

The doughs were prepared by using two methods in which wholemeal barley flour were added directly and as a barley sourdough fermented by starter cultures. In the direct method wholemeal barley flour was used to prepare blends with wheat flour in 0/100, 20/80, 30/70 and 40/60 ratios. Dough pieces were prepared using 250 g of wheat flour or wheat-barley blend, yeasts – 3 g/100 g of flour, salt – 1,5 g/100 g of flour, water in amounts allowing to obtain 300 FU consistency. The dough was mixed on the Brabender farinograph for 3 min at 30 °C, portions of dough were placed in a baking tin and fermented in a temperature of 32–33 °C. Doughs prepared using direct method were kneaded during fermentation three times after 60, 90 and 120 min and then left to final fermentation.

The method using barley sourdough was based on barley sourdough fermented by LV1 starter cultures (containing barley wholemeal flour, water and starter cultures in 1:1:0,005 ratio, fermentation time: 18 h, temperature: 30 °C). Barley sourdough was added to the doughs in amounts allowing to obtain 20/80, 30/70 and 40/60 barley and wheat flour proportions. Water, yeast and salt addition were the same as in the direct method. In this method the dough was kneaded after 30 min of fermentation and left to final fermentation at 30 °C and 85% relative humidity.

In both methods the loaves were baked in a laboratory oven (Brabender, Duisburg, Germany) for 30 min in 240 °C, where the steam was injected right after putting dough in forms into the oven. After baking, loaves were sprinkled with water and left at the room temperature to cool down. Whole baking experiments were performed twice and their averages were reported in the study. Each sample of dough immediately after mixing and after fermentation as well as bread after 24 h was freeze-dried and milled for non-starch polysaccharides content analysis.

2.3. Bread characteristic

After 24 h the bread was evaluated in terms of loaf volume, crust and crumb colour and sensory properties. Bread volume was assessed by millet displacement method using the SA-WY device (ZBPP, Bydgoszcz, Poland), and expressed in cm^3 per 100 g of flour. Breads' crust and crumb colour was measured with Minolta Colorimeter (CR-400/410, Konica Minolta, Japan). Five different points of the slice (crumb) and loaf surface (crust) with L*, a* and b* values were measured. Bread was subjected to sensory evaluation by ten panellists. The questionnaire was based on subjective perception on external appearance, crust and crumb colour, consistency, flavour and taste evaluated on a 9-point hedonic scale.

2.4. Chemical analysis

Total (TDF), soluble (SDF) and insoluble (IDF) dietary fibre content were determined by the enzymatic-gravimetric AOAC method (AOAC, Method 991.43, 2006). For the determination of the content of total (TAX), soluble (SAX) and insoluble arabinoxylans (IAX) colorimetric method was used described previously (Pejcz et al., 2015): The method contained boiling the samples for 1 h with sodium chloride, hydrochloric acid and xylene, cooling and separating the solutions. The upper fractions were taken for further examination by mixing with ethyl aniline and ethanol and then their extinctions were measured at a wavelength of 540 nm and compared with xylose standard curve. For the determination of soluble arabinoxylans the same treatment was conducted with 1 ml of aqueous suspensions extracted for 3 h. Insoluble arabinoxylans fraction content was the difference between total and their soluble fraction. Total β-glucan content was determined with the mixed linkage β-glucan assay kit (Megazyme International, Bray, Ireland) following the ICC Standard Method No. 166. All determinations were performed in duplicate.

2.5. Statistical analysis

The results were statistically analyzed with Statistica 12.0 software package (StatSoft, Tulsa, USA). Two-way (ANOVA for bread quality features at $p = 0.95$ was calculated and three-way (barley share, bread production method, production stage) ANOVA at $p = 0.95$ for chemical compounds content. Homogeneous groups according to Duncan test were estimated and the main effects were presented in the tables.