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Dephytinization of wheat bran by fermentation with bakers' yeast, incubation with barley malt flour and autoclaving at different pH levels

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Abstract

Wheat bran is an important source of dietary fiber but also contains considerable amounts of phytic acid, which is known to impair mineral absorption. The present study was conducted to investigate the phytic acid reduction in coarse and fine wheat bran by fermentation with the different levels of bakers' yeast (3, 6 and 9%) for 8 h at 30 °C, incubation with the different levels of barley malt flour (2.5, 5.0, 7.5 and 10.0%) for 8 h at pH 5.2 and 55 °C, and autoclaving at the different pH levels (pH 5.0, 4.5, 4.0 and 3.5) adjusted with acetic acid for 2 h. The phytic acid content of the wheat bran was effectively reduced by all treatments, and the phytic acid lost was in the range of 88.4–96.9%. Without addition of yeast or malt flour, or autoclaving without pH adjustment, the phytic acid content of the bran samples was reduced at most to 44.9% of the initial amounts under the investigated conditions. Increasing the concentration of yeast or malt flour or decreasing the pH towards 3.5 did not enhance the phytic acid reduction. The most reduction occurred after 2 h of yeast fermentation and malt flour incubation, and after 30 min of autoclaving, which made up 92–98% of the total phytic acid loss. Extending the treatment periods contributed nominally to further increase in the phytic acid reduction, and the rate of the phytic acid loss decreased progressively.

Keywords: Autoclaving; Barley malt flour; Dephytinization; Fermentation; Phytic acid; Wheat bran

1. Introduction

Since modern nutrition programmes have recommended an increased intake of dietary fiber in the light of its nutritional and health benefits, the use of cereal bran in virtually all food product categories has received increased attention. The cereal bran is not only a significant source of dietary fiber and minerals but also an abundant and economical raw material for food processing. However, its nutritional importance is generally compromised by the presence of phytic acid (*myo*-inositol hexakisphosphate) because it has been estimated that more than 85% of phytic acid in the wheat kernel is localized in the aleurone layer (O'Dell et al., 1972).

Being a highly negatively charged molecule at a wide range of pH, phytic acid has been implicated in binding multivalent minerals (i.e. calcium, magnesium, zinc and iron) and interacting with proteins via electrostatic interactions (Champagne et al., 1985; Cheryan et al., 1983; Tangkongchitr et al., 1982). The resultant complexes are mostly insoluble and may reduce the bioavailability and digestibility of minerals and proteins at physiological pH conditions of the gastrointestinal track. These possible harmful effects of phytic acid are recognized as a potential concern in developing countries in which the main components of the diet are cereals and plant foods, and likely to be most pronounced in people suffering from iron-deficiency anemia, pregnant and lactating women, infants and vegetarians. Thus, nutritionists attempt not only to increase the level of dietary fiber but to reduce the level of phytic acid in the diet as well.

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Various biological and food processing methods such as soaking, malting and fermentation activate the endogenous phytases that catalyze the stepwise hydrolysis of phytic acid to *myo*-inositol and orthophosphate through intermediate *myo*-inositol phosphates, while such processing methods as heat treatments (i.e. blanching, baking, autoclaving and frying) cause autolysis of phytic acid (Champagne et al., 1985; Cheryan et al., 1983; Elkhalil et al., 2001; Harland and Harland, 1980; Plaami, 1997; Sandberg, 2002; Tangkongchitr et al., 1981). Each of these processing methods does not provide a complete elimination of phytic acid. In many instances, a considerable amount of phytic acid remains in the processed foods. It is reported that phytic acid can interfere with mineral bioavailability at the dietary levels of 1% or greater, and reducing phytic acid by 90% would be expected to increase mineral absorption several folds (Larsson and Sandberg, 1991; Sandberg and Svanberg, 1991).

In previous studies (Bilgiçli and İbanoğlu, 2007; Egli et al., 2003; Larsson and Sandberg, 1991), the cereal bran (wheat, oat, rye) was incorporated into the different food products, and later processed by different processing methods in order to affect phytic acid reduction. Since the quality of final products is essential, neither the processing methods nor their conditions (i.e. time, temperature and pH) can be changed for the purpose of phytic acid reduction. Thus dephytinization of the cereal bran appears to be reasonable way before its incorporation into the food products.

The objective of the present research was to investigate to what extent it was possible to reduce the phytic acid content of the wheat bran by fermentation with compressed bakers' yeast, incubation with barley malt flour or autoclaving at different pH levels.

2. Experimental

2.1. Sample preparation

Coarse and fine bran samples with the chemical compositions given in Table 1 were obtained from a commercially milled soft white winter wheat, and mixed with deionized, distilled water at the ratios of 1:16 and 2:16 (w/v), respectively. As the degree of phytic acid hydrolysis depends on the process conditions (pH, time and temperature), the bran slurries were divided into three groups and subjected to the following treatments.

2.1.1. Yeast fermentation

The slurries were mixed with 3, 6 or 9% (w/w) of compressed bakers' yeast, and fermented for 2, 4, 6 or 8 h at 30 °C in a temperature controlled water-bath.

2.1.2. Malt flour incubation

The slurries were mixed with 2.5, 5.0, 7.5 or 10% (w/w) barley malt flour (Anadolu Efes Biracılık ve Malt Co., Konya), and kept for one incubation period of either 2, 4, 6 or 8 h at 55 °C in a temperature controlled water-bath after the pH of the slurries was adjusted to 5.2 with acetic acid.

2.1.3. Autoclaving

The pH of the slurries was adjusted to 5.0, 4.5, 4.0 or 3.5 with acetic acid. The slurries were then held at 121 °C for 0.5, 1.0, 1.5 or 2 h in an autoclave.

The bran slurries without addition of yeast or malt flour or without pH adjustment were used as controls, and left resting or autoclaved for the same periods as the related treatment. The slurries taken at 2 h intervals were immediately strained in a sieve (opening 250 μ). The remained solids were rinsed five times with 500 ml of water each time, and dried at 60 °C to a maximum 10% of moisture content. Analyses of the bran samples were carried out in triplicate, and mean values on the basis of dry weight were reported in the tables.

2.2. Proximate analysis

The analyses of moisture and ash contents of the bran samples were carried out according to the ICC standard methods 110/1 and 104/1, respectively (ICC, 2002). Starch and crude fiber were determined by the standard methods of ''Getreide, Mehl und Brot'' (AGF, 1971), and the protein content by the AACC approved method 46-10 (AACC, 2000). pH of the bran slurries was measured by a digital pH meter.

2.3. Total phosphorus and phytic acid

Total phosphorus content was estimated spectrophotometrically using phosphovanadomolybdate method as described by Rickey and Evans (1955), after the bran samples were prepared by the wet ash method (Garcia et al., 1972). Phytate phosphorus was measured by using the colorimetric procedure of Haug and Lantzsch (1983), and phytic acid was calculated accordingly.

2.4. Statistical analysis

For each treatment, sampling was conducted according to a completely randomized experimental design with a factorial arrangement. All statistical analyses were performed using SPSS software (V.11.0 for Windows, SPSS Inc., Chicago, IL). Results were analyzed by three-way analysis of variance

Table 1
Proximate composition of the wheat bran samples

Bran sample	pH	Moisture (%)	Ash (%)	Protein ($N \times 6.25$, %)	Starch (%)	Crude fiber (%)	Phytic acid (mg/100 g)	Total phosphorus (mg/100 g)	Phytate phosphorus (%)[a]
Coarse	6.0	13.4	5.1	12.5	9.1	12.1	2508.8	991.6	71.3
Fine	6.2	12.4	4.4	14.6	11.2	8.4	2296.0	840.9	77.0

[a] As a percentage of total phosphorus.