The effect of wheat variety and flour extraction rate on phytic acid content of bread

Secil Turksoy *, Berrin Ozkaya and Sule Akbas

Department of Food Engineering, Faculty of Engineering, Ankara University, Diskapi Campus, Diskapi 06110 Ankara, Turkey.

*e-mail: turksoy@eng.ankara.edu.tr

Received 20 January 2010, accepted 5 April 2010.

Abstract

Bread made from flours with higher extraction rates is an important source of dietary fibre, however, it also contains considerable amounts of phytic acid. Phytic acid, the major storage form of phosphorus in cereal grains, has always been a matter of concern since it chelates minerals such as iron, zinc and calcium. Effects of wheat variety and flour extraction rates on phytic acid content of bread made from six different wheat varieties (Bezostaya, Gun-91, Dagdas-94, Gerek-79, Kirgiz-95, Ikizce) at four different flour extraction rates (65, 75, 85 and 100%) were evaluated. The contents of phytic acid and total phosphorus of flour and bread samples were determined. The loss of phytic acid content during bread making was also determined. Wheat variety and flour extraction rate significantly affected the phytic acid content (p<0.05) of bread. As the flour extraction rate was increased, the phytic acid and total phosphorus contents of flour samples ranged from 71.8 (Kirgiz-95) to 1054.9 mg/100 g (Gerek-79) and from 66.2 mg/100 g (Ikizce) to 431.0 mg/100 g (Dagdas-94), respectively. For bread samples, the phytic acid and total phosphorus values ranged from 36.8 mg/100 g (Gerek-79) to 451.0 mg/100 g (Dagdas-94), respectively. The phytic acid and total phosphorus contents increased with the increase in the extraction rate of flour and bread samples obtained from each wheat variety. During bread-making process, destruction of the phytic acid decreased as the extraction rate increased. The mean of phytic acid reduction of the bread samples made from flour with 65, 75, 85 and 100% extraction rates were 48.5, 39.4, 31.3 and 21.2%, respectively.

Key words: Phytic acid, total phosphorus, wheat variety, extraction rate, bread.

Introduction

Bread is the staple food in the world and it contributes up to 90% of the calorie intake in some communities. Because of increasing health consciousness and diseases due to malnutrition, bread made from high extraction flour have become more popular. Although the bread made from the high extraction flours are rich in vitamin, mineral and dietary fiber content, they contain some undesirable substances such as phytic acid.

Phytic acid, myo-inositol hexaphosphoric acid, which is the primary storage form of phosphorus in most legumes and cereal grains accounts for 60-90% of total phosphorus in the wheat kernels. Although phytic acid is crucial for plants, it has also some undesirable functions for human body. Phytic acid reacts with proteins, starch and divalent cations such as Zn, Fe and Ca to form insoluble complexes which reduce their functionality, bioavailability, nutritional value and absorption.

Phytic acid content of wheat varies from 0.39 to 1.35% depending on wheat variety and environmental conditions. Previous studies showed that red wheat varieties contained more phytic acid than white wheat varieties. Kernel hardness and season are other important factors affecting phytic acid content. Distribution of the phytic acid in wheat is not uniform in different morphological parts of the kernel. Phytic acid content of flour is significantly correlated with ash content and flour extraction rate since it is generally located in the aleurone layer (more than 80%) and to a lesser extent in the germ and to a lesser extent in the germ (more than 80%) and to a lesser extent in the germ (more than 80%). Depending on bread type, extraction rate of flour and type and time of fermentation and baking conditions in breadmaking process, phytic acid content of breads ranged between 0.28 and 1.05%.

Breadmaking is a multiphase process in which fermentation and baking are the most important phases. Ozkaya et al. indicated that phytic acid content of bread increased by the addition of wheat bran but was reduced by extended fermentation and higher amounts of yeast. The aim of the present study was to investigate the effects of wheat varieties and flour extraction rate on phytic acid contents of the bread made from four different extraction rates of six different bread wheat varieties grown in Turkey.

Materials and Methods

Materials: Six bread wheat samples ( cvs. Bezostaya, Gun-91, Dagdas-94, Ikizce for hard varieties; Gerek79, Kirgiz-95 for soft varieties) were obtained from the General Directories of Agricultural Enterprises (Ankara, Turkey) and Research and Application Farm of Ankara University, Faculty of Agriculture (Ankara, Turkey). After tempering to 15.0% and 16.5% moisture content for soft and hard wheat samples, respectively, the samples were milled on a standard Buhler laboratory mill (Buhler, Co., USA). Coarse and fine brans of each wheat sample were mixed and passed through a bran finisher (Buhler Type MLU-302, Braunschweig, Germany). Flour obtained from the bran was then added back to the respective flour to obtain flour with extraction rate of 65%, 75% and 85%. Brans of each wheat sample were milled using a laboratory mill (Falling Number Type KT-120, Stockholm, Sweden) and the milling...
b) Bran was added back to respective flour to obtain whole wheat flour sample with an extraction rate of 100%.

Methods: The hectolitre weight and kernel vitreousness were determined by using Ohaus test weight apparatus and Grobecker apparatus, respectively. Thousand kernel weight was determined by counting the number of seeds in 20 g of grain. Flour yield of the wheat samples were calculated according to standard methods. Moisture, ash and protein (N x 5.7) contents were determined according to AACC Approved Methods 44-15A, 08-01 and 46-12, respectively. Total phosphorus (P) was quantified according to Rickey and Evans after the samples were prepared by wet ash method. Phytic acid content was determined according to colorimetric procedure.

Breadmaking: Pan bread samples were prepared using flours of six bread wheat varieties at four different extraction rates (65%, 75%, 85% and 100%) according to Rapid-Mix Test. All the bread samples were cooled to room temperature, cut into thin slices and dried at 40°C to a maximum of 10% moisture content. The samples were ground to a particle size of < 0.5 mm by a laboratory mill (Falling Number Type KT30, Stockholm, Sweden) and then stored in polyethylene bags for further analyses.

Statistical analyses: Data from three replications were analyzed by using analysis of variance (ANOVA) procedure of Statistica Package (Statistica for Windows Release 5.0). When significant differences were found, Duncan’s multiple-range test was used to determine the differences among means (p<0.05).

Results and Discussion
The physical and chemical properties of the wheat samples are given in Table 1. Among the wheat samples tested, Gerek-79 and Kirgiz-95 had the lowest number of vitreous kernels. While Bezostaya had the greatest hectolitre weight and thousand kernel weight, Gerek-79 had the lowest values among the wheat samples. The protein content of the wheat samples varied from 10.9 to 14.4%. The ash content showed differences among the wheat samples, ranging from 1.41 to 1.73%.

Phytic acid and total P contents of flour samples with different extraction rates are presented in Table 2. The phytic acid and total P contents of flour samples were significantly influenced by wheat variety and extraction rate (p<0.05). The phytic acid contents of the flour samples increased with increasing extraction rates for each wheat cultivar and ranged from 71.8 to 1054.9 mg/100 g. Wheat kernel does not have a uniform phytic acid distribution, and a major portion of phytic acid is located in the aleurone layer (bran). Therefore, milling of wheat and subsequent separation of bran result in a significant reduction of phytic acid content in flours.

Phytic acid content reported in other studies shows a wide variability depending on extraction rate and flour types. Garcia-Estepa et al. found that the phytic acid values were 4.0 mg/g for white flour and 22.0 mg/g for whole wheat flour. Fbels et al. reported that the phytic acid contents of different flour samples were 3.77 mg/g for hand-made refined flours, 2.96 mg/g for factory-made refined flours and 8.50 mg/g for the whole grain flours. From Ikizce cultivar had the lowest total phosphorus (66.2 mg/100 g) while Dadas-94 gave rise to the highest total phosphorus content (431.0 mg/100 g). Flour samples possessed lower total phosphorus than the phytic acid. In flour samples, the ratios of phytate P as a percentage of total P were found between 29.0% and 73.4%.

The phytic acid and total P contents of bread samples with flour of different extraction rates are given in Table 3. Phytic acid content in breads ranged between 36.8 mg/100 g (Kirgiz-95) and 855.5 mg/100 g (Gerek-79), which increased with the increase in extraction rate. Whole wheat flour breads of different cultivars showed the highest phytic acid contents (642.3-855.5 mg/100 g). Reinhold reported 326-684 mg/100 g of phytic acid in three different bread samples, made from higher extraction flours (75-100%). Similar values were reported for white and whole wheat bread (0.03-0.23% and 0.43-1.05%, respectively). For bread samples of 100% extraction rate, total P content was found to be lower than those of phytic acid due to yeast phytase activity during fermentation process. Total P and phytate P in total P increased with increasing extraction rates. Significant differences in phytic acid and total P contents of the bread samples were observed depending on wheat variety and extraction rate (p<0.05).

During bread-making, the phytic acid content decreased due to activity of phytases as well as high temperature. Similar to results of current study, Tangkonchit et al. reported 23% destruction of phytic acid in bread made with 100% extraction of flour during breadmaking process. Garcia-Estepa et al. used flours with phytic acid contents of 5.4 to 11.3 mg/g for breadmaking and found that the phytic acid values in white and bran breads were 1.48 and 7.53 mg/g, respectively. They also reported that 50% of phytic acid was destroyed during breadmaking. Similarly Gargari et al. showed a significant decrease (approximately 59%) in phytic acid content of flour during breadmaking.

While the highest destruction of phytic acid during the breadmaking process was observed in flour samples from Bezostaya cultivar, the lowest destruction appeared in breads produced with Ikizce flour. In the wheat varieties, the reduction rates of phytic acid content ranged between 18.9% and 50.7%. During breadmaking, the lowest reduction rate for phytic acid was observed in flours with 100% extraction (18.9-23.0%) and the highest in 65% extraction (45.7-50.0%).

Table 1. Some physical and chemical properties of wheat samples.

<table>
<thead>
<tr>
<th>Wheat variety</th>
<th>Hectolitre weight (kg hl⁻¹)</th>
<th>1000-kernel weight (g)</th>
<th>Vitreousness (%)</th>
<th>Protein (N x 5.7) (%)</th>
<th>Ash (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bezostaya</td>
<td>81.8 ab</td>
<td>42.2 ab</td>
<td>60 ab</td>
<td>11.3 ab</td>
<td>1.44 ab</td>
</tr>
<tr>
<td>Gun-91</td>
<td>80.9 ab</td>
<td>33.6 ab</td>
<td>87 ab</td>
<td>14.3 ab</td>
<td>1.61 ab</td>
</tr>
<tr>
<td>Dadas-94</td>
<td>79.3 ab</td>
<td>34.4 ab</td>
<td>81 ab</td>
<td>10.9 ab</td>
<td>1.41 ab</td>
</tr>
<tr>
<td>Gerek-79</td>
<td>77.1 ab</td>
<td>31.0 ab</td>
<td>41 a</td>
<td>14.2 ab</td>
<td>1.73 ab</td>
</tr>
<tr>
<td>Kirgiz-95</td>
<td>80.1 ab</td>
<td>35.9 ab</td>
<td>11 ab</td>
<td>11.4 ab</td>
<td>1.48 ab</td>
</tr>
<tr>
<td>Ikizce</td>
<td>81.0 ab</td>
<td>35.7 ab</td>
<td>89 ab</td>
<td>14.4 ab</td>
<td>1.55 ab</td>
</tr>
</tbody>
</table>

Dry basis. Means followed by different letters in the same column for each properties are significantly different (p<0.05).
Table 2. The phytic acid and total phosphorus contents of flour samples with different extraction rates.

<table>
<thead>
<tr>
<th>E.R. (%)</th>
<th>Wheat variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bezostaya</td>
<td>Gun-91</td>
</tr>
<tr>
<td>65</td>
<td>88.6</td>
</tr>
<tr>
<td>75</td>
<td>118.8</td>
</tr>
<tr>
<td>85</td>
<td>224.5</td>
</tr>
<tr>
<td>100</td>
<td>833.7</td>
</tr>
</tbody>
</table>

Table 3. The phytic acid and total phosphorus contents of bread samples with flour of different extraction rates.

<table>
<thead>
<tr>
<th>E.R. (%)</th>
<th>Wheat variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bezostaya</td>
<td>Gun-91</td>
</tr>
<tr>
<td>65</td>
<td>44.3</td>
</tr>
<tr>
<td>75</td>
<td>70.3</td>
</tr>
<tr>
<td>85</td>
<td>155.0</td>
</tr>
<tr>
<td>100</td>
<td>642.3</td>
</tr>
</tbody>
</table>

Conclusions

Bread made from higher extraction or whole wheat flour is an important source of dietary fiber and minerals, such as Zn and Fe, but their high phytic acid content decreases absorption of these minerals. This study showed that the phytic acid contents of the bread samples made from various wheat cultivars were significantly different from each other (p<0.05). Supplementation of wheat flour with bran caused increases in phytic acid contents as expected. Among all cultivars, the phytic acid contents of bread increased with increasing extraction rate. During the breadmaking process, destruction of phytic acid in breads produced from lower extraction flours was higher than those produced from higher extraction flours. The phytic acid contents of bread samples produced from the whole wheat flour of soft wheat cultivars were found to be higher than those of others.

Acknowledgements

This investigation was supported by Ankara University Scientific Research Projects and The Scientific and Technological Research Council of Turkey (TUBITAK).

References


