Comparative storage studies on wheat flour prepared by different processing methods II.
Effect on phytic acid content in flour and bread

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ABSTRACT

Three months study was conducted on the comparative storage behavior of wheat flour prepared by roller flour mill (FM) and chakki (Cki) milling. Flour was prepared by the two methods from the same lot of wheat, packed in polypropylene woven bags and stored at ambient temperature and relative humidity at Peshawar in the months of May to July. The flour samples were analyzed for phytic acid content in the beginning and at monthly intervals. Leavened and unleavened flat breads were prepared at each storage interval, and among other parameters, were analyzed for phytic acid content. The FM flour contained 0.32% phytic acid and Cki flour 0.55%. In both cases the phytic acid contents did not change for 2 months, but increased slightly in the third month, possibly due to feeding of insect on the endosperm part of the flour. Baking without leavening resulted in slight reduction of phytic acid content, whereas leavening resulted in significant reduction of phytic acid in the resultant bread. This effect of leavening was consistent at all storage intervals as well as in both types of flour. Results of both types of flour were comparable and no specific differences in the storage behavior could be noted with respect to changes in the phytic acid content.

Keywords: Wheat flour, processing, storage, phytic acid

INTRODUCTION

Pakistan has a bread eating culture despite production of substantial quantities of rice. Different variants of flat bread (leavened, unleavened, nan, chapatki) are consumed in different parts of the country which are prepared from high extraction flour called 'atta'. The wheat is milled in roller flour mills or chakkiwals (stone grinders or pin mill grinders). About 80% wheat is consumed in the form of chapattis. It is reported that the per capita consumption of wheat in Pakistan is 124 kg per year or 340 gram per day (Khan 2001). Roller flour mills or modern milling industry grinds approximately 45% of the total wheat consumed in Pakistan and small scale grinders (chakkiwals) grind the remaining 55%. (Khan 2001).

In its natural state, wheat is a good source of vitamin B1, B2, B6, niacin as well as iron and zinc besides being a cheap source of process and calories. But since most of these nutrients are concentrated in the outer layer of the wheat grain, hence a significant portion is lost during the roller-milling process. For more refined wheat flour, the loss of vitamins and minerals is greater as in modern milling sector (Kent 1983). Associated with the bran of cereal grains is a substance, phytic acid (inositol hexaphosphoric acid) which can form insoluble compounds with calcium iron and Mg. More than 90% of the total phytic acid in wheat is localized in the aleurone layer (Pringle 1952) as aleurone grains, which consist almost entirely of phytin, the potassium-magnesium salt of phytic acid (Steven 1971). Phytic acid forms complexes with divalent and trivalent metallic ions such as Zn$^{2+}$, Ca$^{2+}$, Cu$^{2+}$, Fe$^{2+}$, Fe$^{3+}$, especially those which are not absorbed in gastrointestinal tract and thereby lowers the bio-availability of essential elements leading to deficiency diseases and also reduces nutritive value of cereals (Smith and Circle 1978). Brown flour and whole meal flour contain bran and aleurone, and therefore, phytic acid tends to immobilize the calcium and iron present in the flour itself and in other ingredients of diet. Although studies aiming at establishing a direct cause and effect relationship have not yet been conducted, yet it is believed that high phytate diets and lower intake of iron rich food have contributed to the very high prevalence of Iron Deficiency Anaemia (IDA) in Pakistan, severely affecting large sections of the population, particularly young children, pregnant and nursing mothers and female adolescents (GOP, 1985-87).
The purpose of present research was to compare the storage stability and phytic acid contents of wheat flour produced by grinding in roller flour mill and chakki. Effect of baking unleavened and leavened chapatis of the two types of flours on the phytic acid contents was also studied.

MATERIALS AND METHODS

The present research was carried out at Nuclear Institute for Food and Agriculture (NIFA), Peshawar. The flour samples (85% extraction) were obtained from Dastagir flour mills Peshawar. Wheat from the same lot was milled by Chakki (traditional) milling machine (100% extraction rate) and were packed in small (1kg) polypropylene bags. The samples were stored at ambient temperature which ranged from 33-34 °C to 37.73 °C and relative humidity ranged from 40.14% to 64.58% during 3 month's storage period. Samples were analyzed for phytic acid (Haug and Lantzsch, 1993) at 0 days and at monthly intervals thereafter. Leavened (natural) and unleavened chapattis were prepared by traditional method at each storage interval and analyzed for phytic acid content.

Analysis of variance of the data was carried out (2 X 4 factorial RCBD), using MSTAT-C computer package. Means were separated using Dunco's New Multiple Range Test (DNMRT).

RESULTS AND DISCUSSIONS

Phytic Acid in Flour samples

Two types of flours, prepared by roller Flour Milling (FM) and Chakki were used in these studies. Since the extraction rate, bran content and the proximate composition of both the flour types were different, therefore it was expected that the nutrient availability, storage behavior, acceptability and other parameters of nutritional significance would also be different in both types of Atta (Khan, 2001).

Roller milled and chakki flours prepared from the same wheat lot were studied for their total phytic acid contents. The average phytic acid contents of the chakki flour were 0.56% as compared to 0.30% in the FM flour (Table 1). Effect of storage and milling method on phytic acid content are shown in Fig 1. The phytic acid contents were 0.32% in FM flour and remained almost unchanged during the entire storage period. Phytic Acid contents of the chakki flour also did not change significantly for 2 months (0.55 to 0.56%) but increased significantly in the third month.

Table 1. Effect of flour type and storage on the phytic acid content (% of wheat flour

<table>
<thead>
<tr>
<th>Flour Type</th>
<th>Storage - Months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 Month</td>
</tr>
<tr>
<td>FM Mill</td>
<td>0.32 ±0.04</td>
</tr>
<tr>
<td>Chakki</td>
<td>0.55 ±0.24</td>
</tr>
<tr>
<td>Mean</td>
<td>0.43 ±0.21</td>
</tr>
</tbody>
</table>

Values are means of three replications ± standard deviation. Values in a row or column followed by different letters are significantly (p<0.05) different from each other.

Increase in the phytic acid contents was not an increase in the amount of phytates per se, rather the concentration of phytic acid increased due to drying out of the samples as well as insect infestation, which was observed in present case during the last month of the storage (Tariq 2003). Since the insects feed upon the endosperm part of the flour, the concentration of the bran portion increased, and consequently resulted in an overall increase in the concentration of phytic acid.

Differences in storage behaviour of the two types of flours, in terms of PA contents, can be explained on the bases of composition of the two flours. Due to the removal of bran portion in the roller milling process the bran contents and hence the concentration of PA is reduced in the flour. That logically reduced the impact of insect infestation on the PA contents.

Phytic acid is present in the range of 1-5% of many cereals, legumes and oil seeds (Reddy et al. 1982). The phytic content in the wheat flour varies according to the extraction rates. Batten (1994) compared the concentration of minerals and phytic acid in 47 different wheat samples and observed that Australian
wheat contained only 59-77% of the phytic acid as compared to the white and red wheat grown overseas. Becker and Lorenz (1978) found that the amount of phytic acid varied from 0.40 to 2.0% in legumes, from 0.5 to 1.89% in cereals and from 2 to 5.20% in oil seed.

Phytic acid in chapati samples

Table 2 shows the phytic acid content of the leavened (L) and unleavened control (C) chappatis prepared from freshly milled as well as stored flours of both types. The data revealed that the differences in phytic acid contents of the two types of flour were reflected also in the baked products. Chapattis from Chakki resulted in a significant breakdown of their phytic acid content (Kumar et al. 1978 and Reddy 1987). However, Ologhobo and Fatuga (1984) could not record a significant reduction in phytic acid of soybean due to cooking, autoclaving and soaking. Nevertheless, Microwave heating of soybean caused a 23% phytic acid reduction after 9 minutes and 46% after 15 minutes (Hafiz et al. 1989). Poonam and Sahil (1993) reported reduction in phytic acid content in the processed weaning food, after mixing locally available cereals (wheat, barley and pulses). Mameesh and Tomar (1993) observed that fermentation of soybean fortified wheat flour resulted in complete removal of phytic acid.

<table>
<thead>
<tr>
<th>Flour Type</th>
<th>0-Month</th>
<th>1-Months</th>
<th>2-Months</th>
<th>3-Months</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>F.Mill-C*</td>
<td>0.30±0.02</td>
<td>0.28±0.03</td>
<td>0.29±0.01</td>
<td>0.33±0.01</td>
<td>0.30±0.01</td>
</tr>
<tr>
<td>F.Mill-L**</td>
<td>0.24±0.03</td>
<td>0.23±0.01</td>
<td>0.24±0.01</td>
<td>0.26±0.01</td>
<td>0.24±0.01</td>
</tr>
<tr>
<td>Chakki-C</td>
<td>0.45±0.03</td>
<td>0.41±0.01</td>
<td>0.47±0.01</td>
<td>0.46±0.01</td>
<td>0.44±0.01</td>
</tr>
<tr>
<td>Chakki-L</td>
<td>0.28±0.09</td>
<td>0.24±0.01</td>
<td>0.24±0.01</td>
<td>0.28±0.01</td>
<td>0.26±0.01</td>
</tr>
<tr>
<td>Mean</td>
<td>0.32±0.02</td>
<td>0.29±0.01</td>
<td>0.31±0.01</td>
<td>0.33±0.01</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Effect of flour type and storage on the phytic acid contents (%) of bread

C = Unleavened control, ** = Leavened
Values are means of three replications ± standard deviation
Values in a row or column followed by different letters are significantly (p<0.05) different from each other.

flour contained higher (P<0.05) concentration of phytic acid than those prepared from roller milled flour. Effect of leavening (natural fermentation for two hour) was significant (P<0.05) on the phytic acid contents of both the flours. As observed in the case of flours, the phytic acid contents increased in the chappatis prepared in the later stages of storage. This effect of storage, however, was more pronounced in the case of Chakki flour chappatis as compared to roller milled flour chappatis.

Studies on legumes, cereals and oilseeds have shown that phytic acid is generally stable under ordinary processing conditions (Thompson 1990). Pure phytic acid in aqueous solution at pH 6.0 was lost at about 50% after 1-hour autoclaving (De Boland et al. 1975), but in biological systems e.g. in cereals and oilseeds less than 10% loss was observed with autoclaving for 0.5-2.0 hours (Lease 1996). Boiling of legumes also
Advantages of the acidic environment and the lengthy fermentation of sourdough bread include the breakdown of phytates - increasing mineral bioavailability, increased digestibility, and decreased rate of spoilage. The binding of phytic acid with minerals is pH dependent and the complexes formed with different cations have varying solubilities. Phytic acid also binds protein molecules (Schwenke et al. 1986 and Moth et al. 1987). Protein-phytic acid complex is insoluble but may become soluble when the pH decreases below 3 (Cheryan 1980).

Phytic acid is hydrolyzed to phosphoric acid and inositol by the enzyme phytase, present in the seed. Maximum phytase activity occurs at 55°C. Probably 60% of the phytic acid in flour is hydrolyzed during bread making (Kent 1983). Brune et al. (1992) reported that effective fermentation would increase bioavailability of iron in whole-wheat flour bread.

In conclusion it can be said that the amount of phytic acid was higher in Chakki flour as compared to roller flour milled atta. Leavening resulted in substantial reduction in the phytic acid contents of the flour. Although the sensory properties (Tariq 2003) of the flat bread prepared from the flour remained within the acceptable limit (>5), it can be concluded that a reasonable storage period for the wheat flour, under the given climatic conditions and the existing packing system, should not more than 45 days.

REFERENCES


