Sensory Characteristics of Whole Wheat Mineral Fortified Chapattis

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Abstract: This study aimed to find out the impact of iron and zinc fortification of Whole-Wheat Flour (WWF) on the acceptability of chapatti. An additional aim was to select suitable storage conditions for fortified flour. Fortified flours were packed in polypropylene woven bags and stored under controlled and ambient conditions of temperature and relative humidity. Chapattis prepared from fortified flours were evaluated for color, taste and flavor. The storage conditions, storage periods and treatments of the flour samples significantly (p<0.05) affected the color, taste and flavor of chapattis. The sensory study of the mineral fortified chapattis revealed that the flour fortified with NaFeEDTA in combination with ZnSO₄ or ZnO, stored under controlled conditions is the better choice for organoleptically acceptable mineral fortified chapattis.

Key words: Mineral, fortification, flour, chapatti, organoleptic

Introduction
Iron deficiency is extremely common and affects one-third of the preschool children and one-half of the women of reproductive age in lower income countries (WHO, 2001). Because absorbable forms of iron and zinc are found in many of the same foods, these high rates of iron deficiency provide evidence of widespread occurrence of zinc deficiency (Christine and Kenneth, 2004).

Flour fortification ensures an even meal distribution of added iron and provides a reasonably constant iron supply to each individual. Several countries in Latin America, the Middle East and North Africa are implementing flour fortification programs for wheat and corn flour with iron and other micronutrients. However, there is little experience in developing countries with fortification with zinc (Mehansho and Mannar, 1999).

Wheat flour is a staple food of Pakistani people with an average intake of 318 g/person/day. More than fifty percent of the total energy intake is derived from wheat flour (OMNI, 1996). Wheat flour is a good vehicle for delivering additional iron in Pakistan because it is so widely consumed and because iron can be added with no effect on product quality or appearance and at very low cost (Cook and Reusser, 1983). Elemental iron powders are widely used for food fortification particularly for the fortification of cereal flours and other cereal products, such as breakfast cereals and complementary foods. There is little direct evidence, however, that elemental iron powder have a beneficial effect on iron status (Hurrell, 2002).

One of the major problems in iron fortification has been the development of unacceptable color changes in fortified foods (Sayer et al., 1974). Organoleptic problems related to zinc fortification of food have not been reported and do not seem to be a major concern (Clydesdale, 1991).

Off flavor can also result from the metallic taste of the soluble iron itself, particularly in beverages. However, the catalytic effect of iron on fat oxidation in cereal during storage is the major problem. As in case of product discoloration, water soluble compounds such as ferrous sulfate promote fat oxidation and reduce product shelf life (Hurrell et al., 1989). Food Chemical Codex (1981) requires that reduced iron powders used for fortification pass through a 100-mesh sieve (<149 µm) and that electrolytic iron and carbonyl powders pass through a 325-mesh sieve (<44 µm), this is not sufficient to guarantee adequate absorption even though most reduced iron powders used to fortify cereal foods in industrialized countries have a particle size<44 µm. NaFeEDTA is a pale yellow color powder with a fine particle size. The objective of this project was to study the effects of different iron and zinc compounds, added to the WWF in different combinations and dose levels on the sensory attributes of WWF chapatti and thereby help to develop a palatable, low cost, nutritionally important mineral based bread to overcome highly prevalent micronutrients deficiency in the populations of developing countries.

Materials and Methods
Procurement of whole-wheat flour and fortificants: A popular Pakistani wheat variety, Inqulab 91, was used for the production of whole-wheat flour and was procured from the Post-Graduate Agricultural Research Station, University of Agriculture Faisalabad, Pakistan. Elemental iron, sodium iron ethylene diamine tetra acetate (NaFeEDTA), zinc oxide and zinc sulfate were used as fortificants. The iron fortificants were obtained from the Miconutrient Initiative (MI), CIDA Program Support Unit Pakistan office Islamabad, whereas zinc fortificants were received from Fortitech Inc., New York, USA. Reduced iron, a brittle material in the powder form.
Table 1: Treatment combinations of zinc and iron used in whole wheat flours

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<thead>
<tr>
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<th>T₀ (ppm)</th>
<th>T₁ (ppm)</th>
<th>T₂ (ppm)</th>
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<tbody>
<tr>
<td>Control</td>
<td>NaFeEDTA 40</td>
<td>NaFeEDTA 60</td>
<td>Elemental iron 40</td>
<td>Elemental iron 60</td>
<td></td>
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<tr>
<td></td>
<td>ZnSO₄ 20</td>
<td>ZnO 20</td>
<td>ZnSO₄ 30</td>
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Fig. 1: Effect of storage conditions on colour scores of different flours

Fig. 2: Effect of storage periods on colour scores of different flours

Fig. 3: Effect of treatments on colour scores of different whole wheat flours

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that this color and taste may be imparted to the end product when used in WWF. Conversely, it was also a consideration that the iron fortificant had been used in the flour with a very little flour to mineral ratio so no effect on sensory attributes could be observed. WWF in contrast to white flour was selected in this study as a vehicle for fortification because of its many advantages over white flour. These include the use of WWF by a greater segment of the local population, contains more concentration of micronutrients and fiber content and the use of NaFeEDTA which is recommended to be used in WWF because it does not bind with phytic acid owing to its chelating effect of EDTA moiety in the compound. Unlike leavened pan bread, chapatti is prepared with out any ingredient except water. Obviously there is no yeasty, sweet or bitter taste in chapatti. So the panel members specifically rated the chapattis based on the presence or absence of brown to blackish tinge and metallic to non metallic taste.

Color: The color scores of the chapatti samples prepared from flours stored in ambient conditions significantly differed from the color of the chapattis made from flours stored under controlled conditions (Fig. 1). There was a progressive decrease (p<0.05) in color scores of the chapattis over the entire storage period. (Fig. 2). The chapattis prepared from fresh fortified WWF were moderately liked by the panel members as compared to the chapattis of 60 days stored flours which they did not assign their liking or disliking to. This deteriorative process of color may be attributed to multiple reasons and the foremost is itself the color of iron fortificant that had likely appeared gradually in the product. Fig. 3 indicates a comparison of the sensory qualities of the chapattis with respect to the treatment. The color scores were found to be the highest (6.49) for chapattis prepared from unfortified WWF and the minimum scores were given to the chapattis prepared from flour fortified with elemental iron and zinc oxide (4.71). The flour containing elemental iron imparted blackish color to the chapatti. All the treatments differed significantly for color of chapattis. Sayer et al. (1974) reported that one of the major problems in iron fortification has been the development of unacceptable color changes in fortified foods. Rehman et al. (2006). conducted similar type of studies with naan (a flat bread prepared from white flour of 75% extraction rate. They reported that iron levels significantly affected sensory characteristics of these breads including color, texture, flexibility, chewability and overall acceptability. The flours containing NaFe EDTA imparted less color in the chapattis as compared to the flours containing elemental iron. Garby (1985) supported this view point by reporting that iron compound may also provoke precipitation when added to foods and impart
Fig. 4: Effect of storage conditions on flavour scores of different flours

Fig. 5: Effect of storage periods on flavour scores of different flours

Fig. 6: Effect of treatments on flavour scores of different flours

Flavor: Panelists rated the chapattis of the flours stored under controlled condition to be better as compared to the chapattis made from the flour stored at ambient conditions (Fig. 4). It is evident from the data that fortification of flour had a deteriorative effect on the flavor of the chapattis. The concentration of the iron in the flour seemed to have a direct effect on this sensory property of the chapattis. The flavor scores of the chapattis in different treatment combinations decreased with an increase in iron concentration in the flour (Fig. 5). Zinc fortificants are expected to have a little or no effect on the flavor of chapattis and concentration of iron irrespective of the source obviously affected this sensory attribute. It may be presumed that zinc salts are organoleptically least problematic when compared with iron salts as they possessed white color and used in relatively lesser concentration. OMNI (1996) reported that iron is a pro-oxidant and is involved in major flavor changes in fortified foods, especially those that require longer shelf-life including wheat and corn flour. Off flavor can also result from the metallic taste of the soluble iron itself. However, the catalytic effect of iron on fat oxidation in cereal during storage is the major problem. The scores of flavor affected by fortificants may be due to the role of prooxidant nature of iron. The storage of the fortified flours for 60 days had significant effect on the flavor of the chapatti (Fig. 6). Chapattis of fresh flour got higher scores for flavor as compared to the chapattis of flours stored for various time intervals. It is evident from a number of studies on wheat flour that flour undergoes various physico chemical changes during storage. Sur et al. (1993) studied the effect of temperature and RH on the quality of flour under storage similar to those used in the present study. They found protein, gluten, sedimentation value, starch and crude fat decreased during storage in all the samples, free amino acids,
proteolytic activity, diastatic activity and damaged starch decreased with increase in storage period. Chapatti making properties of stored flour were inferior to that of fresh counterparts. Such a decline in flavor scores of chapattis in fortified flours during storage may be ascribed to these physicochemical changes.

**Taste:** There was no significant effect of storage conditions of the flours on the taste of the chapatti however, the length of storage of flours significantly affected (p<0.05) taste of the chapattis prepared from these flours. The highest scores were assigned to the taste of chapattis prepared from fresh flour (0 day storage) while the lowest scores were obtained for the chapattis prepared from flours at 45 and 60 days storage, respectively (Fig. 7). The judges discriminated between chapattis prepared from fortified and unfortified flours. The chapattis prepared from unfortified flour got maximum scores for taste i.e. (6.31) while chapattis prepared from flours treated with elemental iron and zinc oxide were rated to be at the bottom with respect to the taste (Fig. 8). The reason that may be assigned to these effects is the use of elemental iron with zinc oxide in relatively higher doses. Harrison et al. (1976) reported that the samples of unbleached flour enriched with different iron sources were stored at 50°C and 23°C. At 50°C, a rancid smell was detected with ferrous sulfate after 4 days and after 11-28 days with reduced iron. Anonymous (1968) reported that bread and cake flour enriched with different sources, including ferrous sulfate, were stored at room temperature and at 27°C. Baking tests and peroxide value, indicative of oxidative rancidity, run after 3 and 6 months of storage showed no difference that could be attributed to a single iron source. Kent (1966) reported bitter taste in breakfast cereal products as a result of storage. He correlated the bitter taste with peroxidase activity. Peroxidase was found to be apparently the most thermo stable of any of the enzymes that could be involved in bitter taste during storage of flours. Development of off-flavors presents a challenge to food scientists who attempt to fortify foods with iron compounds (Hurrell, 2002). Ranum (1999) reported that flour contains a small amount of fat, the addition of ferrous sulphate can reduce its acceptable shelf life such as flour for commercial bakeries but it can cause unacceptable flavor development in house hold flour after months of storage but reduced iron is considered safe in any type of flour even that requiring extended storage period.

**Conclusion:** The present study indicated that the chapatti prepared from flours with elemental iron as iron fortificant was not liked but remained acceptable for taste by the panel of judges and that may be attributed to the metallic taste of the elemental iron used in relatively higher concentration that was indicated in the end product. It was further concluded that NaFeEDTA is even better as iron fortificant with respect to sensory characteristics of the chapatti of fortified flours though it is relatively expensive and fortification cost may increase which is one of the major concern for the manufactures and consumers as well. The fortified flours stored under controlled conditions and stored for less than one month remained highly acceptable to the panel of judges.

**References**
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