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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 $ZnSO_4$ 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 Micronutrient 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

T_0	T_1	(ppm)	T_2	(ppm)	T_3	(ppm)	T_4	(ppm)
Control	NaFeEDTA	40	NaFeEDTA	60	Elemental iron	40	Elemental iron	60
	Zn_2SO_4	20	Zn O	20	Zn_2SO_4	30	Zn O	30

with very fine particle size (80%<20 µm), grey black in color, odorless, magnetic and dissolved in dilute mineral acids was used as an iron fortificant in the present research project.

Level of fortification: Different levels of fortification of both zinc and iron in each treatment group were used to investigate the combined effect of these minerals on sensory attributes rather than to evaluate the effect of individual fortificant within a group. The levels and combinations of fortificants used in this study are given in Table 1.

Iron-flour premix: Mineral flour premix was prepared using iron and zinc fortificants. In the fortification of flour the required nutrient mixture was mixed with an appropriate diluent to produce a premix, which was then accurately mixed into the flour.

Fortification: A volumetric screw type feeder was used to add premix to the flour in a continuous system of flour fortification. Proper agitation of the premix in the hopper was ensured to avoid bridging and tunneling during the flow of the premix. A small overage of micronutrients was added to make sure the formulations met the level claimed in the fortification.

Sampling: Fresh samples of fortified and unfortified flours were collected at a point in the production line after the addition of the fortificants.

Packaging and storage of fortified flour: The fortified WWF samples packed in polypropylene woven bags and were, stored for a period of 60 days under controlled and ambient conditions. The controlled condition was maintained at a storage temperature ranging from 23-25°C with relative humidity 45-55% and ambient condition represented 35-42°C with relative humidity 30 to 70%.

Preparation of chapattis: Chapattis were prepared from fortified WWF samples by following the method outlined by Haridas *et al*. (1986). The dough for chapattis was made by mixing 200 g of flour with pre determined amount of water for three minutes in a mixer and allowed to rest for 1 hour at room temperature. A dough piece weighing 80 g was rounded and turned to chapatti by using a specially designed platform. An open rectangular wooden frame was placed in the groove provided on the platform to facilitate the rolling of the dough. The rolled dough sheet was then cut into a circle of 18 cm in diameter using a dye with a sharp edge. The chapattis were of uniform thickness (3mm). The chapattis were baked on a thermostatically controlled hotplate at a temperature of 210°C for 150 seconds. The size, weight and volume of the chapattis were monitored during baking.

Sensory evaluation of chapattis: Sensory testing was conducted in the Institute of Food Science and Technology, University of Agriculture Faisalabad, Pakistan. The chapattis were analyzed using hedonic scale in accordance with the method described by Larmond (1977). The panel members were selected on the basis of their ability to discriminate and scale a broad range of different attributes. Some panel members were hired from the industry and were paid for the analysis. An orientation program was organized for the panel members to brief them of the objective of the project and were shown the entire method of chapatti preparation to better understand the chapatti attributes. The chapattis were prepared and immediately brought to the sensory analysis lab. After cooling for 30 minutes under ambient condition the chapattis samples were packed in plastic zip bags. These bags were coded with random numbers and served to the panelists. The sensory testing was made in the panel room with controlled temperature and relative humidity. The panel room was completely free of food/chemical odors, unnecessary sound and mixing of daylight. The panelists were provided with prescribed questionnaires to record their sensory observation. The information contained on the sensory performa was indicated as 9 = Like extremely; 8 = Like very much; 7 = Like moderately; 6 = Like slightly; 5 = Neither like nor dislike; 4 = Dislike slightly;3 = Dislike moderately;2 = Dislike very much;1 = Dislike extremely.

The panelists expectorated the chapattis and rinsed mouth using distilled water between samples. The ten samples were evaluated and replicated in seven days. This evaluation process lasted for two months with five periodical analyses.

Statistical analysis: Data were analyzed statistically using analysis of variance and four factor factorial as described by Steel *et al*. (1996). Duncan's Multiple Range Test was applied to assess the difference between means (Duncan, 1955).

Results and Discussion

Formulations shown in Table 1 were developed keeping in view the nutritional status and mineral requirement of

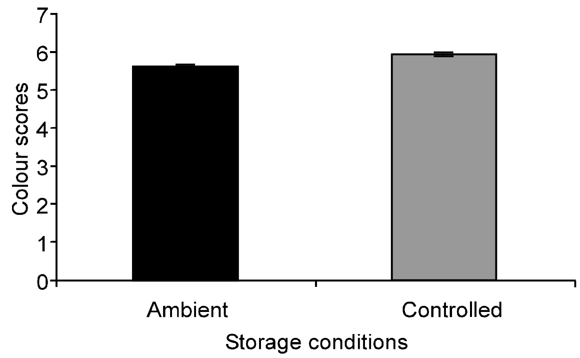

Fig. 1: Effect of storage conditions on colour scores of different flours

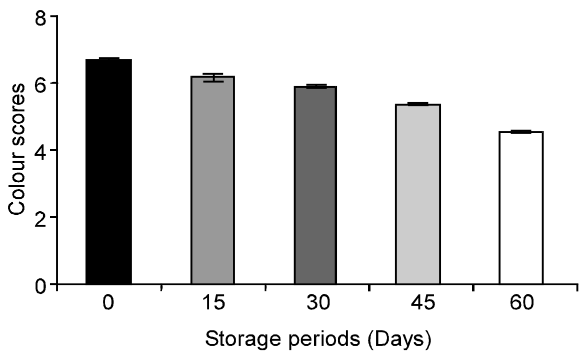

Fig. 2: Effect of storage periods on colour scores of different flours

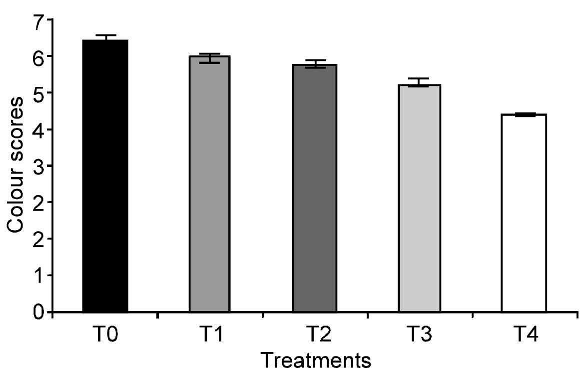

Fig. 3: Effect of treatments on colour scores of different whole wheat flours

the population. WWF fortification with these concentrations of elemental iron, zinc sulfate and zinc oxide have been widely reported but there is little evidence to support the use of NaFeEDTA as an iron fortificant in the wheat flour. NaFeEDTA is a highly bioavailabe iron compound and a maximum concentration has been used to find out its effect on the sensory attributes of the chapattis made from these flours. As the iron compounds carry darker color with a metallic taste, based on these facts, it was hypothesized 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 fortificants 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 fortificants 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 chapattis. 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

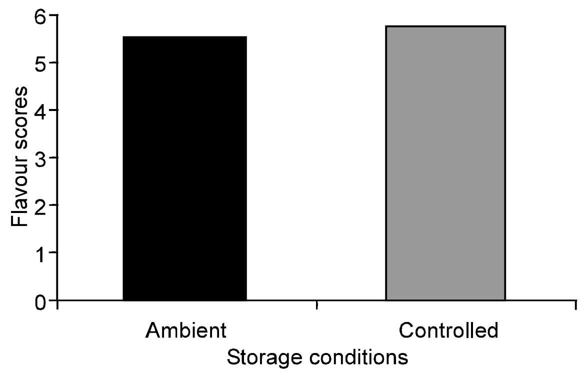

Fig. 4: Effect of storage conditions on flavour scores of different flours

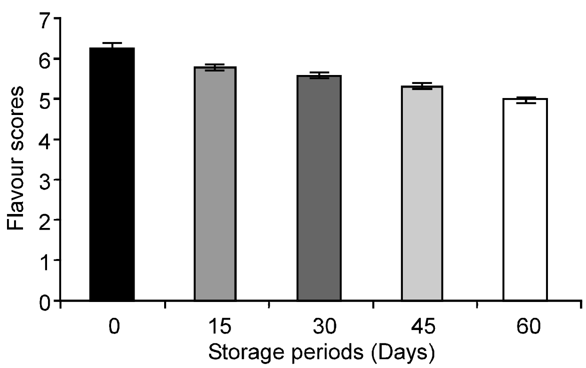

Fig. 5: Effect of storage periods on flavour scores of different flours

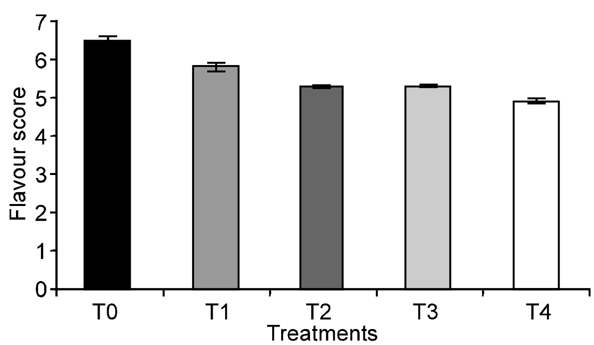

Fig. 6: Effect of treatments on flavour scores of different flours

unacceptable changes in color and flavor of the product. Clydesdale (1991) reported that organoleptic problems related to zinc fortification of food have not been observed and do not seem to be a major concern. Ranhotra *et al.* (1977) reported no adverse effect on bread quality after addition of 2.2 mg Zn/100g to wheat flour as acetate, sterate, carbonate, chloride, oxide, sulfate or elemental zinc. Disler *et al*. (1975) reported that Fe (III) EDTA is a pale yellow water soluble powder with a high stability constant and there should thus not be a major problem in finding a suitable dietary ingredient to serve as vehicle for fortification. No important color changes have been reported in the vehicles tested so far. Barret and Ranum (1985) reported that the physical color of the iron compounds themselves may carry over in the fortified product. Sufficient literature is available to support that temperature and relative humidity during storage affect the quality of the cereal flours and this effect might be indicated in the end product. Iron and zinc fortificants are hygroscopic in nature and are directly affected by the concentration of moisture in the surrounding. Changes in atmospheric temperature of the product might have an influence on the reactivity of the iron and zinc compounds with flour components. Flour moisture changes can support the acidity alterations caused by the enzymatic breaking of fytin by fytase, lipolytic fat hydrolysis and proteolysis (Hansen and Rose, 1996).

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 pro oxidant 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,

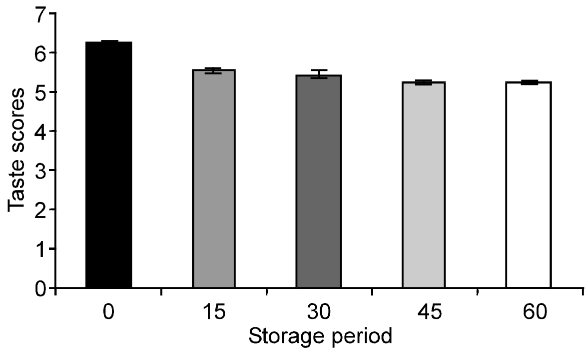

Fig. 7: Effect of storage periods on taste scores of different flours

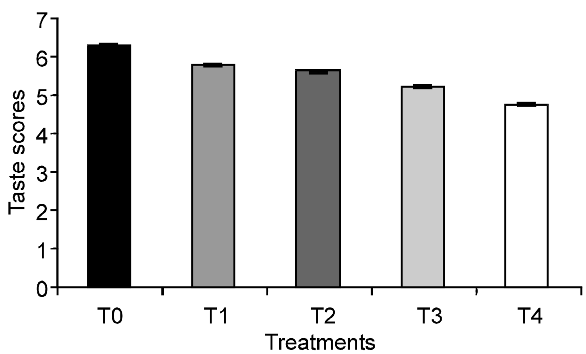

Fig. 8: Effect of treatments on taste scores of different flours

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 physico chemical changes.

Taste: There was no significant effect of storage conditions of the flours on the taste of the chapattis 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 chapattis 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.

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