Organoleptic Effects of Flour Fortification

Flour fortification, when appropriately implemented, does not significantly affect the organoleptic qualities (color, smell or taste) of food. It also does not significantly affect the baking attributes of flour. The table below lists 12 studies which reference this. Following the table is a summary of each study for more information.

Study	Country	Product tested	Fortificants	Results
Influence of micronutrients on rheological characteristics and bread-making quality of flour	India	Bread	ferrous sulphate, calcium carbonate and vitamins such as thiamine riboflavin, niacin (nicotinic acid) and folic acid	Addition of either iron or calcium salts from different sources had no significant effect on the farinograph, alveograph and micro-visco amylograph characteristics of wheat flour. Addition of vitamin-mineral premix did not alter the bread-making quality of flour. Addition of premix at a 1% level increased the iron and calcium content in breads four to six times than that of the control.
Effects of various iron fortificants on sensory acceptability and shelf-life stability of instant noodles	Thailand	Instant noodles	ferrous sulfate(FS) , NaFeEDTA and encapsulated H reduced elemental(EEI) iron	The addition of any of the three fortificants to noodles did not significantly change their sensory properties or shelf-life stability as compared with the unfortified noodles. NaFeEDTA produced the least differences in color and flavor of the fortified product as compared with the unfortified product. All fortified instant noodles were well accepted by consumers.
Effect of fortification on physico-chemical and microbiological stability of whole wheat flour	Pakistan	Flour	NaFeEDTA, elemental iron, $ZnSO_4$ and ZnO	The fortification exhibited a slight deteriorative effect on chemical composition of whole wheat flour and the textural characteristics of chapattis made from such flours.

Nutrient addition to corn masa flour: Effect on corn flour stability, nutrient loss, and acceptability of fortified corn tortillas	Mexico	Tortillas	vitamin B1 (thiamine mononitrate), vitamin B2 (riboflavin hydrochloride), zinc (zinc oxide), iron (elemental reduced iron)	Sensory evaluation indicated that the fortified corn flour tortillas were well accepted by Mexican adults.
Comparative studies on storage stability of ferrous iron in whole wheat flour and flat bread (naan)	Pakistan	Naan	ferrous iron and folic acid	Among the treatments, naan produced from flour containing 50 ppm ferrous iron exhibited the best in overall characteristics when subjected to sensory evaluation.
Evaluate the quality characteristics of bread baked with vitamin B12.	United States	White pan bread	B12	The addition of vitamin B12 does not impact dough handling or fermentation rates of white pan breads up to 1000 micrograms per 100 g ram of flour. Subjective evaluation ratings of breads with vitamin were slightly higher than the control breads. The addition of vitamin B12 at levels up to 1000 micrograms did not produce a noticeable red or pink crumb color.
Quality of bread fortified with ten micronutrients	U.K.		thiamin, niacin, riboflavin, iron, vitamin A, pyridoxine, folic acid, calcium, magnesium, and zinc	Vitamins are retained well in the bread, and no loss occurred during baking or storage of the product. None of the premixed had any detrimental effect on structure and appearance of the bread, and no off color was noticed in bread stored up till five days at room temperature and four weeks at freezer temperature.
Sensory trial to assess the acceptability of zinc fortificants added to iron-fortified wheat products	United States	Bread & noodles	iron sulfate , zinc sulfate & zinc oxide	Noodles fortified with zinc oxide are slightly less preferred by subjects than those fortified with zinc sulfate. Overall the zinc-fortified products were in general well liked by the subjects in the study.

Laboratory and consumer tests to compare fortified wheat-flour products to products made with unfortified wheat. Products were tested for colour, texture, and sensory effect.	Malaysia	Noodles, sandwich bread and roti canai	Electrolytic iron, ferrous fumarate, ferrous sulphate, folic acid, vitamin B1 and vitamin B2	Noodle samples made with wheat flour fortified with ferrous sulphate produced products with undesirable organoleptic properties. Fortificants premix with (ferrous fumarate, folic acid, thiamine and riboflavin) produced noodles, sandwich bread and roti canai with comparable quality to control sample (unfortified sample) in terms of processing properties, colour, texture and sensory qualities. However, noodle products become slightly yellow when produced using the premix. This is a desirable characteristic for yellow alkaline noodles and instant noodles but might be a disadvantage for dried noodles or particularly any type of white salted noodles.
Cake and all-purpose wheat flours were fortified with iron and folic acid and tested for shelf stabilities under accelerated conditions.	Thailand	Angel cake, cookies and fresh alkaline noodles	Ferrous sulfate, ferrous fumarate, elemental iron, H-reduced EI, electrolytic EI, folic acid.	As compared to ferrous sulfate, elemental irons (i.e. H-reduced and electrolytic) were more appropriate due to insignificant effects on sensory quality. Folic acid did not affect sensory quality and was also stable during storage.
Acceptability of Complementary Foods and Breads Prepared from Zinc-Fortified Cereal Flours among Young Children and Adults in Senegal	Senegal	Complementary foods and bread	Complementary foods: iron alone iron and zinc Bread (acceptability test): iron and folic acid iron and zinc Bread (threshold test): Zinc in increasing increments	All products were accepted by participants when compared to similar items processed without zinc as a fortificant. Adults were able to detect differences in bread taste when 80 mg, 160mg and 320 mg of zinc were added but not when the bread was fortified with 240 mg and 400 mg of zinc. The levels suggested for fortification did not impact the acceptability of either the complementary foods or the bread products.
Asian Wheat Flour Products: Impact of flour fortification on organoleptic properties.	China, India, Malaysia, Sri Lanka Philippines, India	15 kinds of noodles and bread	All included: Iron, folic acid Some included: B12, vitamin A, thiamin, riboflavin, and zinc	The organoleptic differences between fortified and non-fortified products were not considered a deterrent to acceptability. Micronutrients appeared to be retained throughout the food preparation process.

Influence of Micronutrients on Rheological Characteristics and Bread-Making Quality of Flour

Journal: *International Journal of Food Sciences and Nutrition*, March 2008; 59(2): 105_115

Link: http://informahealthcare.com/doi/abs/10.1080/09637480701497170

Overview

The study analyzed the influence of different iron and calcium salts along with some vitamins on the rheological characteristics and bread-making quality of wheat flour. Fortification with iron (30-90 pparts per million - ppm) from different sources showed a marginal increase in water absorption (2%). Calcium ranging between 800 and 1600 ppm did not show any influence on the mixing properties of the dough. Addition of a micronutrient premix containing ferrous sulphate, calcium carbonate and vitamins such as thiamine (thiamine hydrochloride), riboflavin, niacin (nicotinic acid) and folic acid at different levels showed a marginal effect on the rheological parameters. No significant influence of micronutrient premix on the objective and subjective evaluation of the breads was noted, except for the crumb color. Fortification with the vitamin-mineral premix did not affect the rheological parameters and bread-making quality of flour, even after storage.

Method

The commercial wheat flour used in the studies had 11.2% moisture, 0.45% ash and 9.45% protein. Ferrous sulphate, iron EDTA and ferrous fumarate salts were mixed with flour to form a premix, such that if premix is used at 0.5%, 1.0% and 1.5% it would provide 30, 60 and 90 ppm of iron, respectively. Different sources of calcium, such as calcium carbonate, calcium lactate, calcium phosphate and calcium citrate were used to provide levels of 0.8, 1.2 and 1.6 g/kg calcium flour. Among B-group vitamins, thiamine (thiamine hydrochloride 0.65 mg/100 g), riboflavin (0.75 mg/100 g), niacin (nicotinic acid 5.0 mg/100 g) and folic acid (150 mg/100 g) along with iron as ferrous sulphate (6 mg/100 g) and calcium as calcium carbonate (120 mg/100 g) were used to prepare the vitamin-mineral premix. The nutrient premix was added to fortify flour at 0.5%, 1% and 1.5% levels.

Conclusions

Fortification of flour with micronutrients in relation to bread-making quality is feasible. Adding either iron or calcium salts from different sources to wheat flour has no significant effect on the farinograph, alveograph and micro-visco amylograph characteristics of wheat flour. Addition of vitamin-mineral premix did not alter the bread-making quality of flour. Addition of premix at a 1% level increased the iron and calcium content in breads four to six times than that of the control.

Effects of Various Iron Fortificants on Sensory Acceptability and Shelf-life Stability of Instant Noodles

Journal: *Food and Nutrition Bulletin*, vol. 28, no. 2, 2007, The United Nations University

Overview

In this study, the feasibility of fortifying instant noodles with different forms of iron fortificants ferrous sulfate (FS) , ferric sodium ethylenediaminetetraacetic acid [NaFeEDTA], and encapsulated H reduced elemental(EEI) iron was evaluated, and the fortified noodles were compared with unfortified noodles for changes in physical, chemical, and sensory qualities.

Methods

For the formulation of instant noodles, approximately 200 g of wheat flour was mixed with each iron fortificant for 10 minutes at a dosage to provide 5 mg of iron per serving (one 50-g package of instant noodles). One 50 g serving of instant noodles was prepared from 43g of wheat flour or about 61 g of wheat dough. To ensure the even distribution of the iron fortificants, four blocks of instant noodles sampled from each preparation batch were analyzed for total iron contents. The homogeneity of the different iron fortificants in instant noodle blocks showed that there were no significant differences in total iron contents among four block pieces of all noodle samples ($p > .05$). The iron contents ranged from 10.54 to 10.80, 10.81 to 11.06, and 9.65 to 9.83 mg per 100 g OR 5.27 ± 0.10, 4.27 ± 0.07, and 5.26 ± 0.47 mg per serving of noodles fortified with FS, NaFeEDTA, and EEI, respectively (data not shown). Therefore, all iron-fortified noodles used in this study had close to 5 mg of iron per 50-g instant noodle block.

Results

Sensory acceptability

The general appearance scores of iron-fortified cooked noodles were not significantly different from those of unfortified noodles ($p > .05$). The color suitability scores of fortified noodles also showed no significant differences from the unfortified noodles. The overall acceptability scores of iron-fortified noodles were not significantly different from those of unfortified noodles. The elasticity and softness suitability scores of both fortified and unfortified noodles were acceptable to the panelists. No metallic odor was observed in any fortified noodles.

Color

The raw noodle dough sheet, instant noodles, and cooked noodles fortified with FS had significantly lower values of L* and b* (the color quality measured by L*, lightness and b*, yellowness) and significantly higher values of a* (redness) than the unfortified products. No color changes were observed with the addition of NaFeEDTA. The product that was fortified with FS had more red and yellow tone, whereas the color values of noodles fortified with NaFeEDTA were almost similar to those of the unfortified samples.

Sensory evaluation
During the three months of storage, there were no significant differences in color between fortified and unfortified noodles, except for EEI-fortified noodles, which were rated as darker.

Conclusion
The addition of any of the three fortificants to noodles did not significantly change their sensory properties or shelf-life stability as compared with the unfortified noodles. NaFeEDTA produced the least differences in color and flavor of the fortified product as compared with the unfortified product. All fortified instant noodles were well accepted by consumers. During three months of storage at room temperature, the iron fortificants did not adversely affect the peroxide value, color, or sensory quality of the noodles as compared with unfortified noodles.

Effect of Fortification on Physico-chemical and Microbiological Stability of Whole Wheat Flour

Journal: *Food Chemistry* 110 (2008) 113–119
Link: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T6R-4RSRDPH-3&_user=655046&_rdoc=1&_fmt=&_orig=search&_sort=d&_docanchor=&view=c&_searchStrId=1081505469&_rerunOrigin=google&_acct=C000034138&_version=1&_urlVersion=0&_userid=655046&md5=4242a0e861103dfbb803133103c86f28

Overview
The objective of this study was to evaluate the extent of mould contamination in fortified whole wheat flour (WWF) stored under different conditions for an extended time period. Stability of fortified WWF was evaluated using NaFeEDTA, elemental iron, ZnSO4 and ZnO as fortificants. Fortified WWF was stored in tin boxes and polypropylene bags for 60 days under ambient storage condition (ASC) and controlled storage condition (CSC).

Results
Effect of fortificants on proximate composition
Fortification significantly decreased moisture content of WWF. The type of iron fortificant affected the outcome as higher reduction ($p < 0.05$) in moisture was observed in flour samples fortified with elemental iron as compared to those containing NaFeEDTA. Zinc fortificants did not exert any effect on moisture in all treatments.

Effect of fortificants on textural characteristics of chapatti
The chapattis in Indian subcontinent should be soft, pliable in texture with good chewiness and desirable mouth feel. The addition of fortificants influences these attributes with loss in chapatti quality. The judges discriminated between chapattis prepared from fortified and unfortified flours for these quality parameters. The chapattis prepared from unfortified flour got maximum scores for texture, flexibility and

chewiness. The quality loss quantified in terms of percentage suggested 15%, 8% and 11% for texture, flexibility and chewiness of chapattis, respectively as compared to the control.

Conclusion

The fortification exhibited a slight deteriorative effect on chemical composition of whole wheat flour and the textural characteristics of chapattis made from such flours.

Nutrient Addition to Corn Masa Flour: Effect on Corn Flour Stability, Nutrient Loss, and Acceptability of Fortified Corn Tortillas

Journal: *Food and Nutrition Bulletin*, vol. 26, no. 3, 2005, The United Nations University

Overview

This study evaluated the stability of corn flour fortified with micronutrients (iron, zinc, thiamin, and riboflavin) and measured the effect of micronutrient fortification on the sensory quality and stability of the fortificants in fresh and stored tortilla.

Methods

A commercially homogenized non-fortified corn flour was used for the study. The micronutrient mixture source consisted of a dry powder comprising vitamin B1 (thiamine mononitrate), 8mg/kg, vitamin B2 (riboflavin hydrochloride) 4 mg/kg , zinc (zinc oxide), 30 mg/kg and iron (elemental reduced iron) 30 mg/kg. A panel of 30 “tasters” was used for the evaluation.

Results

Physicochemical and microbiological characteristics of fortified corn flour

Initial moisture content was 13% (± 0.70%) for fortified corn flour (FCF) and 12.9% (± 0.55%) for non-fortified corn flour (NFCF) and remained constant during storage. Initial water activity value (Aw) obtained for NFCF and FCF was 0.506 and 0.548, respectively. There were no changes in Aw of both formulations during storage. The storage stability of corn flour after micronutrient fortification and NFCF did not show lipid oxidation (measured as peroxide index) even after 90 days storage at 22°C. Also, total plate count did not show any significant changes and no molds or yeasts were detected over 90 days of storage, indicating that the product was microbiologically stable during storage.

Micronutrient stability of FCF and NFCF during storage

The content of thiamin and riboflavin in the FCF was 1.1 mg/100 g and 0.6 mg/100 g. Thiamin content in FCF did not show any significant change within the first 15 days of storage, but a significant decrease of 13% was observed in NFCF during this period ($p < .05$). When storage was prolonged to 90 days, decreases in thiamin content of 24% for FCF and 35% for NFCF were observed, corresponding to a final content of 0.83 mg/100 g and 0.19 mg/100 g for FCF and NFCF, respectively.

Vitamin B2 (riboflavin) losses of 10% were observed in both samples within the first 30 days of storage at 22°C. After 90 days of storage, loss of vitamin B2 in both samples was very similar, reaching values of 18% for FCF and 22% for NFCF. The final content of riboflavin at the end of the storage period in FCF and NFCF was 0.49 mg/100 g and 0.19 mg/100 g, respectively. The iron content in FCF and NFCF was 4.5 mg/100 g and 2.8 mg/100 g respectively; while the zinc content was 2.0 mg/100 g for NFCF and 4.1 mg/100 g for FCF. The stability of iron and zinc in fortified corn flour stored at room temperature was good.

Sensory evaluation of tortillas made from stored corn flour

Fortified tortillas received favorable flavor and odor evaluations, with a DOL (degree of likeliness) of 5.3 and 5.6, respectively. The color of both samples of tortilla was less acceptable (3.6 to 4.0). There were no differences in DOL in either sample of tortillas made with corn flour previously stored for 90 days as compared with samples taken at time zero; thus flour storage did not affect the acceptability of tortillas.

Conclusions

Storage time slightly affected the stability of riboflavin and thiamin in FCF, which was acceptable during the first three months. FCF had losses of 24% for thiamin and 18% for riboflavin. No significant losses in iron and zinc content were observed during the period of storage. Sensory evaluation indicated that the FCF tortillas were well accepted by Mexican adults.

Comparative Studies on Storage Stability of Ferrous Iron In Whole Wheat Flour and Flat Bread (Naan)

Journal: *International Journal of Food Sciences and Nutrition*, February 2007; 58(1): 54_62
Link: http://www.informaworld.com/smpp/content~db=all~content=a769604122

Overview

Whole wheat flour (WWF) was fortified with premix containing ferrous sulfate, ethylenediamine tetraacetic acid and folic acid (20.0:20.0:1.5 ppm) and was stored at ambient temperature for 60 days. Naans (flat bread) were prepared from 0 ppm, 25 ppm, 50 ppm and 75 ppm ferrous iron-fortified flour samples at 10-day intervals and were analyzed for physicochemical constants and sensory evaluation.

Methods

WWF was fortified with a premix at levels of 0 ppm, 25 ppm, 50 ppm and 75 ppm ferrous iron and folic acid (0 ppm, 1.5 ppm, 3.0 ppm and 4.5 ppm). The fortified samples were packed in cotton bags and stored at ambient temperature (i.e. 29-38^{0}C) for 60 days. Naans were prepared from stored ferrous non-fortified and iron-fortified flours at 10-day intervals. Preparation of naan of both types of flour (i.e. non-fortified and fortified with iron premix) was carried out by traditional methods.

Results

Effect of storage on total iron and ferrous contents of iron-fortified WWF and naan

The total iron of WWF increased as a result of fortification with iron. The highest quantity of iron was found in flour containing 75 ppm ferrous sulfate, followed by the sample containing 50 ppm ferrous sulfate. Statistical analysis shows that total iron content changed non-significantly during a storage period of 60 days while conversion of ferrous to ferric iron took place, affecting the bioavailability of iron.

Organoleptic evaluation

The naans were prepared at 10-day intervals from non-fortified and iron-fortified, stored WWF and were evaluated for various sensory attributes. An increase in ferrous level significantly affected the color, texture, flexibility, chewability and overall acceptability of the naans. The quality score for color of naans revealed that as the level of ferrous iron increased, the brown color of the naan increased. Mostly, naan is prepared from white flour of 75% extraction rate. Naan produced from WWF of 100% extraction rate was brownish because of high bran content, which obscures browning imparted by iron, making it a useful vehicle for iron fortification.

Increasing levels of ferrous iron in flour showed no effect on the taste and flavor of the naans. The texture softness was not affected significantly up to the 50 ppm addition of iron fortificant. Similar trends were observed in the flexibility, chewability and overall acceptability of the naans. The analysis indicates that storage periods adversely affected the color, taste, flavor, texture, flexibility, chewability and overall acceptability of the naans.

Conclusion

During storage of ferrous iron-fortified flour, the total iron was not affected significantly, but the ferrous iron content decreased as a result of oxidation. Iron levels significantly affected sensory characteristics (P5 0.05), including the color, texture, flexibility, chewability and overall acceptability of the naans, except taste and flavor. Among the treatments, naan produced from flour containing 50 ppm ferrous iron exhibited the best in overall characteristics when subjected to sensory evaluation. Naan produced from flour containing 75 ppm not only exhibited less texture softness, but also affected the overall acceptability. Storage of iron-fortified flour beyond 60 days can adversely affect the sensory characteristics of naans.

Quality of Bread Fortified with Ten Micronutrients

Journal: *Cereal Chemistry 57(1);1-3*
Link: http://www.aaccnet.org/cerealchemistry/backissues/1980/chem57_1.pdf

Overview:
Many cereal grain products in the United Kingdom are fortified with thiamin, niacin, riboflavin, iron, and calcium. In view of many changes in the consumption pattern, food technology and marketing, the food and nutrition board upgraded information on enrichment of cereals that included vitamin A, pyridoxine, folic acid, calcium, magnesium, and zinc. This study report results of the study done to determine if the micronutrients impart any adverse flavor changes to bread.

Methods
Two different lots of flour with slight differences in the content for ash, protein, and moisture were used for the study. The flour was fortified with micronutrient to achieve the recommended level. The bread was evaluated by a 10 member panel to detect flavor changes in the product.

Results
Flour was fortified by adding full vitamin and mineral levels except for magnesium and calcium which were added at one-third and two-thirds of the recommended level. Further analysis showed bread was highly over fortified with minerals including zinc, suggesting that natural mineral content of the cereal grain products must be considered before adding micronutrients, especially those that might cause off flavor.

The experiment was repeated with unfortified flour that was assayed for natural vitamin and mineral contents, and minerals were added to account for this natural level. The results from the study show that vitamins are retained well in the bread and no loss occurred during baking or storage of the product. None of the premixed had any detrimental effect on structure and appearance of the bread, and no off color was noticed in bread stored up to five days at room temperature and four weeks at freezer temperature.

Conclusions
The study demonstrated that fortification of bread with the proposed micronutrient is feasible. As some minerals are present in flour and some are in formula ingredients, the natural micronutrient content of the flour and the nutrients contributed by the formula ingredients should be taken in account.

Quality Characteristics of White Pan Bread Fortified with Vitamin B_{12}

Link: http://www.sph.emory.edu/wheatflour/inpractice.php

Overview

The study conducted by the American Institute of Baking evaluated the quality characteristics of bread baked with vitamin B_{12}

Methods

Sponge and dough white pan breads were prepared under controlled conditions within the given guidelines. Vitamin $B_{12}$was added to breads at levels of 700, 800, 900, and 1000 micrograms per 100 g of flour in the formulation. The crystalline vitamin B_{12} was diluted to a concentration of 50micrograms/ml of water for addition to the bread formulation. These breads were compared to a control with no added vitamin.

Results

The addition of vitamin B_{12} to the dough had no effect on sponge or dough handling characteristics. No discoloration or change in fermentation properties was noted in the sponge or dough with the above levels of B_{12}. Computer generated software was used to measure crumb fineness and cell shape, and the fineness scores of the breads containing B_{12} were very similar to the control bread. Subjective evaluations of the bread samples were also found to be very similar. Crumb color of the breads with any level of B_{12} was rated slightly higher than the control

Conclusions

The addition of vitamin B_{12} does not impact dough handling or fermentation rates of white pan breads up to 1000 micrograms per 100 g of flour. Subjective evaluation ratings of breads with vitamins were slightly higher than the control breads. The addition of vitamin B_{12} at levels up to 1000 micrograms did not produce a noticeable red or pink crumb color

Sensory Trial to Assess the Acceptability of Zinc Fortificants Added to Iron-fortified Wheat Products

Journal: *Journal of Food Science*, Vol.67, Nr.1, 2002
Link: http://www3.interscience.wiley.com/cgi-bin/fulltext/118909543/PDFSTART

Overview

This study compared the acceptability of bread and noodles made from wheat flour fortified with iron sulfate alone or iron sulfate and high or low levels of either zinc sulfate or zinc oxide in an adult U.S. population. The research was conducted as part of a broader effort to develop a program of zinc fortification of wheat flour in Peru.

Method

The products were manufactured following Peruvian recipes for bread and noodles. The recipes for French bread and noodles are similar to those used in the United States. Three types of breads were produced using white wheat flour fortified with (per kg. of flour):

- 30 mg of iron as ferrous sulfate
- 30 mg of iron as ferrous sulfate, and 100 mg of zinc as zinc sulfate
- 30 mg of iron as ferrous sulfate and 100 mg of zinc as zinc oxide

Breads were prepared from the fortified wheat flour, water, lard, salt, sugar, and yeast.

The five types of noodles were fortified with (per kg of flour):

- 30 mg of iron as ferrous sulfate
- 30 mg of iron as ferrous sulfate and 60 mg of zinc as zinc sulfate
- 30 mg of iron as ferrous sulfate and 60 mg of zinc as zinc oxide
- 30 mg of iron as ferrous sulfate and 100 mg of zinc as zinc sulfate
- 30 mg of iron as ferrous sulfate and 100 mg of zinc as zinc oxide.

The products were evaluated on the degree of liking (DOL) of the preparation for flavor, texture using a 9-point hedonic scale.

Results

The three types of breads were generally well liked, with a mean overall DOL of 6.7. There were no significant differences among bread samples in DOL for flavor ($p = 0.59$), texture ($p = 0.82$), or overall ($p = 0.66$).

The overall mean DOL of all noodle preparations was 5.7, indicating good acceptability. However, there were small differences by type of fortificants in the DOL for flavor ($p = 0.013$), texture ($p = 0.008$), and overall ($p < 0.0001$). Specifically, the DOL of flavor, texture, and overall for noodles fortified with iron and zinc oxide were significantly less than for the other two types of noodles.

Conclusion

Noodles fortified with zinc oxide are slightly less preferred by subjects than those fortified with zinc sulfate. Overall the zinc-fortified products were in general well liked by the subjects in the study.

Effect of Wheat Flour Fortification on the Quality of Noodles, Sandwich Bread and Roti Canai

Source: The project was fully funded by the Ministry of Malaysia, and the research was conducted at the Interflour-Universiti Teknologi Mara Research and Development and Commercialisation Centre in Malaysia.

Overview:

This study compared the effect of fortification on wheat flour and the impact that fortified wheat had on the color, texture, and sensory qualities of noodles, sandwich bread, and roti canai. Water absorption of noodles was also measured.

Method

Flour for the study was supplied by Prestasi Flour Ptd. Ltd. (Port Klang, Malaysia), and all fortificants were supplied by Fortitech Sdn. Bhd. (Malaysia).

For noodles, fortification used in the following categories, in addition to a control group:

1. Electrolytic iron 4.33 mg/100g
2. Ferrous fumarate 12.78 mg/100g
3. Ferrous sulphate 13.13 mg/100g
4. Folic acid 170 ug/100g
5. Electrolytic iron and folic acid (same rate as above)
6. Ferrous fumarate and folic acid (same rate as above)
7. Ferrous sulphate and folic acid (same rate as above)
8. Ferrous fumarate, folic acid, (same rate as above) plus vitamin B1 (0.53 mg/100g) and vitamin B2 (0.71 mg/100g)

For bread, flour was fortified with ferrous fumarate, folic acid, vitamin B1 and vitamin B2 at the same rates listed above. A control group of unfortified flour was also used for tests with bread.

To ensure even distribution, all fortificants were added into 25 kg of wheat flour which was pre-mixed with 200 g of wheat flour. Then the flour was mixed with 24.8 kg of wheat flour for 10 min using a double cone mixer. Colour was measured using a Konica Minolta CR-410 chromameter.

Results

Results for each product tested are:

- Wheat flour: The colour of wheat flour was similar irrespective of the fortificants variations. The low dosage of fortificants addition does not resulted in any colour changes in wheat flour.
- Yellow Alkaline Noodles: Few color differences were noted except noodles made with ferrous fumarate and ferrous sulfate were rated as duller in colour as compared to the control noodles. The overall surface appearances, elasticity, smoothness and overall texture quality of all noodles were equally good as they were rated with the similar score with control. All yellow alkaline noodles produced in this study were acceptable.

- Instant Fried Noodles: All samples resulted in dough crumbs which were creamy, moderately bright and crumbly. Dough sheets were streaky, not sticky and easy to handle during dough sheeting. In terms of colour, samples made with ferrous sulfate were dull and unacceptable.
- Dried Noodles: all fortificants used in this study resulted in dough crumb and dough sheet similar with control. The colour of noodles made with ferrous fumarate or ferrous sulfate were slightly duller than the control group. The overall surface appearances, elasticity, smoothness and overall texture quality of all noodles were equally good as they were rated with the similar score with control.
- Sandwich Loaf: Fortification of bread flour with ferrous fumarate, folic acid, vitamin B1 and B2 did not result in any significant colour changes on the bread produced. Fortified flour resulted in softer bread as compared to the unfortified flour. This might be due to the different moisture content in those breads, which was attributed to the ability of mineral salts such as ferrous fumarate and folic acid to retain moisture. When sensory properties of both fortified and unfortified bread were compared, no distinguishable different could be observed except for the slightly brighter colour observed on unfortified bread (control).
- Roti Canai: The dough colour of fortified roti canai was slightly more yellow than control. However, when dough was coated with margarine and further pan-fried, colour of the dough for fortified roti canai was comparable to control. During flipping of the roti canai, it was noted that dough of fortified roti canai was slightly stiffer than control but still considered as comparable. When sensory properties of both fortified and unfortified roti canai were compared, no distinguishable different could be observed in term of softness, crispiness and chewiness. Generally, fortification resulted in roti canai with similar quality with unfortified flour.

Conclusion

Noodle samples produced using wheat flour fortified with ferrous sulfate produced products with undesirable organoleptic properties in terms of colour and overall appearance. Therefore, it can be concluded that ferrous sulfate is not a preferable for wheat flour fortification. Fortified flour produced noodles, sandwich bread and roti canai with comparable quality to those made with unfortified flour in terms of processing properties, colour, texture and sensory qualities. However, noodle products become slightly yellow or when produced using the premix. This is a desirable characteristic for yellow alkaline noodles and instant noodles but might be a disadvantage for dried noodles or particularly any type of white salted noodles.

Flour Fortification Initiative

A PUBLIC-PRIVATE-CIVIC INVESTMENT IN EACH NATION

Sensory Acceptability and Nutrient Stability of Double-Fortified Wheat Flour

Source: Mahidol University graduate student thesis by Chakkrapong Assawapromtada with thesis advisors Visith Chavasit, and Anadi Nitithamyong, both of whom have doctorates in food science.

Overview

Due to increased wheat flour consumption in Thailand, flour is being considered as a vehicle for delivering micronutrients to the population. This test was designed to study the sensory acceptability of foods made with flour that had been fortified with both iron and folic acid. The study also examined the nutritional stability of the food products after a storage period.

Method

Cake (low extraction) and all-purpose (high extraction) wheat flours were fortified with iron and folic acid. Each kind of wheat flour was fortified with:

- Iron: 51 parts per million (ppm) either ferrous sulfate or ferrous fumarate, or 101.85 ppm from elemental iron (either H-reduced or electrolytic)
- Folic acid: 1.4 ppm

Angel cake, cookies, and fresh alkaline noodles were prepared with the fortified flour as well as a control flour that was not fortified. Products were packed in three types of bags: polyethylene bag which is normally used in the lower income market, laminated film bag which is normally used in higher income markets, and woven polypropylene bags which are used for industrial distribution. Products were tested for shelf stability under accelerated conditions (fluorescent light, 40± 2ºC) at the beginning then at the first, second and third month.

During storage, the flour products were analyzed for color and oxidative rancidity by spectro-colorimeter and thiobarbituric acid reactive substances (TBARS) respectively; difference from control on rancidity and color by sensory evaluation (n=24); iron and folate retention by Atomic Absorption Spectrophotometer and microbiological assay (*Lactobacillus casei*), respectively; and moisture content and water activity by oven drying and water activity meter.
For sensory evaluation, samples were coded with a three-digit random number and randomly served to 24 adult panelists.

Results

Ferrous fumarate affected sensory quality the most, therefore it was eliminated from the study.
TBARS of products made with fortified and unfortified flours increased slightly, but significantly during the first months (0.41-0.71 to 1.10-1.90 mg MDA/kg), and increased substantially in the third months (1.10-1.90 to 2.00-3.43 mg MDA/kg). Significant differences in rancidity intensity were found in flour fortified with ferrous sulfate after two to three months storage. Colours of all fortified flour products were significantly different from unfortified flours; however they were not significantly detectable by sensory evaluation. Reductions in moisture content and water activity during storage were significant with final values of 9-10% and 0.33-0.45, respectively. After 3 months storage, there were no significant changes in iron content, and more than 90 percent of the folate was retained. The highest losses of folate in

unfortified flours were 17-25%. Per serving, foods made with flour fortified with ferrous sulfate and elemental iron provided 10.5 and 20.4% of the recommended daily intake of iron respectively; and 21% RDI of folic acid.

Conclusion

It was feasible to fortify cake and all-purpose wheat flours with iron and folic acid, which were distributed in commercially-used packaging i.e. polyethylene bag, laminated film bag, and woven polypropylene bag. As compared to ferrous sulfate, elemental irons (i.e. H-reduced and electrolytic) were more appropriate due to insignificant effects on sensory quality. Folic acid did not affect sensory quality and was also stable during storage. Moisture content and water activity of the stored wheat flours decreased significantly, especially in the woven polypropylene bag. Bioavailability of the iron fortificants needs to be further studied considering the wheat flour consumption patterns of people in Thailand.

Acceptability of Complementary Foods and Breads Prepared from Zinc-Fortified Cereal Flours among Young Children and Adults in Senegal

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Overview: Zinc is an important micronutrient for proper growth, immune function and pregnancy. Individuals living in low-income regions are particularly at risk for zinc deficiency due to limited intake of absorbable zinc and infections which impair zinc absorption. A *Lancet* series on maternal and childhood undernutrition suggests that zinc deficiency can be attributed to 4% of annual deaths in children under 5 years old. In order to address these issues, fortification of cereal grain products with zinc has been implemented in some countries.

Objectives:

1. Assess acceptability of zinc-fortified cereal-based complementary foods among children and their caregivers
2. Assess acceptability of varying levels of zinc-fortified bread among adults

Methods:

<u>Trial 1: Acceptability of zinc-fortified complementary foods</u>

Apparently healthy children 12-17 months of age and weight for length z-scores of ≥2 were recruited from low-income areas of Dakar, Senegal. All children had to be accustomed to consuming complementary foods with a spoon. Researchers obtained a commercially-produced, non-fortified, cereal-based complementary food from a local entity. Two batches were created to include different levels of zinc. <u>Batch A</u>: 60 mg ferrous fumarate per kg dry weight of the complementary food with no zinc.

<u>Batch B</u>: same quantity of ferrous fumarate along with 240 mg zinc oxide per kg dry weight of the complementary food. A practice session took place the day before the trail to familiarize caregivers with the experiment process. On each of the subsequent two days, a portion of complementary food from one of the two study batches was offered randomly to the participants during midmorning (60 minutes after arrival to site). The total time required to consume the meal along with the amount of product left over (if any) was recorded. Caregivers were asked to approximate their child's impression of the food using a modified 7-point hedonic scale. The child's emotional state prior to food consumption was noted as well.

A triangle taste test was then conducted with the caregivers to see if they could differentiate between the batches of complementary foods. They were asked to discuss flavor, texture and overall degree of liking.

Trial 2: Acceptability and threshold of zinc-fortified breads

Acceptability:

Apparently healthy males and females over 18 years old were recruited as employees of the Senegalese Food Technology Institute. Non-fortified wheat flour was collected and micronutrients were added in varying quantities to create three different batches of baguette dough. Batch A: 15 mg ferrous fumarate and 1.5 mg folic acid per kg of flour. Batch B: Same as Batch A with the addition of 63 mg of zinc oxide per kg of flour. Batch C: Same as Batch A with addition of 126 mg zinc oxide per kg of flour. The trial lasted two days. On the first day, participants were given a baguette representing each of the three batches of dough. No butter or spreads were offered. On the second day, the test was repeated but with the option of adding butter. The baguettes were rated by the participants based on appearance, flavor, texture and overall degree of liking.

Threshold:

For the threshold trial, males and females over 18 years old from a catchment area near the test center in Dakar-Yoff were requested to participate. Five different batches of baguette dough were prepared using methods described previously. Batch A: unfortified. Batch B through E were fortified with zinc oxide from 80-400 mg per kg of flour in 80 mg increments. The final products were not visually different. For the trail, a 2-5 test was utilized during which a participant received 5 samples, two of one batch and 3 of another. Participants were asked to separate the batches into groups, so that the groups contained the same products. Unfortified bread was always paired with baguettes fortified with zinc. Over two days, participants completed five 2-5 tests.

Results:

Trial 1: Acceptability of zinc-fortified complementary foods

Pooling both days of observation, children consumed, on average, 7g less of the complementary food fortified with zinc (P=0.016). However, excluding children who had symptoms of illness on the day of the trial resulted in a non-significant finding (P=0.147). Similar results were noted when reviewing duration of feeding. Mean values of the caregivers proxy hedonic ratings were favorable for both products at $\geq$ 5.3 (indicating positive experiences with the products). Caregiver ratings were also high for both complementary products. During the triangle test, caregivers were only able to correctly distinguish 25.4% of the samples.

Trial 2: Acceptability and threshold of zinc-fortified breads

Participant ratings were high for all products, with no significant differences noted for appearance, flavor, texture or overall degree of liking. When served with butter, ratings were significantly higher for flavor, texture and overall degree of liking (all P<0.001). In comparing the batches of baguettes fortified with 0 mg zinc to 240 mg and 400 mg of zinc, the probability of distinguishing the samples was less than the probability of correctly differentiating the breads merely by guessing. However, when comparing the 0 mg samples to breads fortified with 80 mg, 160 mg and 320 mg of zinc, 24-29% of participants correctly grouped the baguettes into their respective groups. This was statistically significant.

Conclusions:

Study results indicate that the addition of zinc to complementary foods and bread using fortified wheat flour was acceptable to the participants, thus indicating that flour fortification with zinc may be acceptable to a larger population in West Africa. However, short term trials may not be a clear indicator of long-term intake.

Asian Wheat Flour Products:
Impact of flour fortification on organoleptic properties

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Overview:

In 2009, the World Health Organization (WHO) and its partners published the *Recommendations on Wheat and Maize Flour Fortification Meeting Report: Interim Consensus Statement*. The document provides guidelines for the fortification of industrial-milled wheat and maize flour with iron, zinc, folic acid, B12 and vitamin A. Between August and October 2009, researchers in China, India, Indonesia, Malaysia, the Philippines and Sri Lanka conducted a series of studies on commonly eaten noodle and bread products produced with wheat flour fortified based on WHO recommendations. The goal: see whether or not the WHO recommendations would be compatible and acceptable for products regularly consumed in Asia.

Objectives:

1. Examine the effects of fortified flour on processing and food technology, especially with regard to local recipes and production processes.
2. Evaluate the sensory and physical attributes of flour fortified based on WHO recommendations and the resulting food products
3. Evaluate the retention of nutrients in the end-product (cooked or ready-to-eat)

Methods:

The FFI East Asia Secretariat coordinated and facilitated tests of 15 food products in six Asian countries to gain insight about the objectives listed above. The research agencies in each country were asked to compare products prepared with fortified flour to their counterparts prepared with unfortified flour based on the following parameters: color, texture, taste, fortificant level (before and after preparation), noodle crumb, water absorption, cook yield, and sensory evaluation. Fortification levels were based on WHO recommendations.

Results:

Overall, the differences between fortified and unfortified products were minimal and did not impact general acceptability of the products. Noodles and bread prepared with NaFeEDTA iron were slightly darker in some cases. In the Philippines, the dough for bread products occasionally contained brown spots, but the final products were deemed acceptable. In India, fortified chappati and puri were actually preferred over their non-fortified counterparts. A rancidity experiment in Malaysia indicated that fortification may impact the shelf life of instant noodles. However, the review was conducted one year after the product was produced even though the shelf life is only supposed to be 4 to 6 months.

Conclusions:

Any organoleptic differences between fortified and non-fortified products were not considered a deterrent to acceptability. Micronutrients appeared to be retained throughout the food preparation process though assessment methods varied by country. These results suggest that utilizing wheat flour fortified at levels designated as optimal by the WHO is not only feasible but largely acceptable for Asia’s food industry.