24th Annual IAOM Mideast & Africa Conference and Trade Show
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Detection and Measurement of Iron Compounds in Fortified Flours

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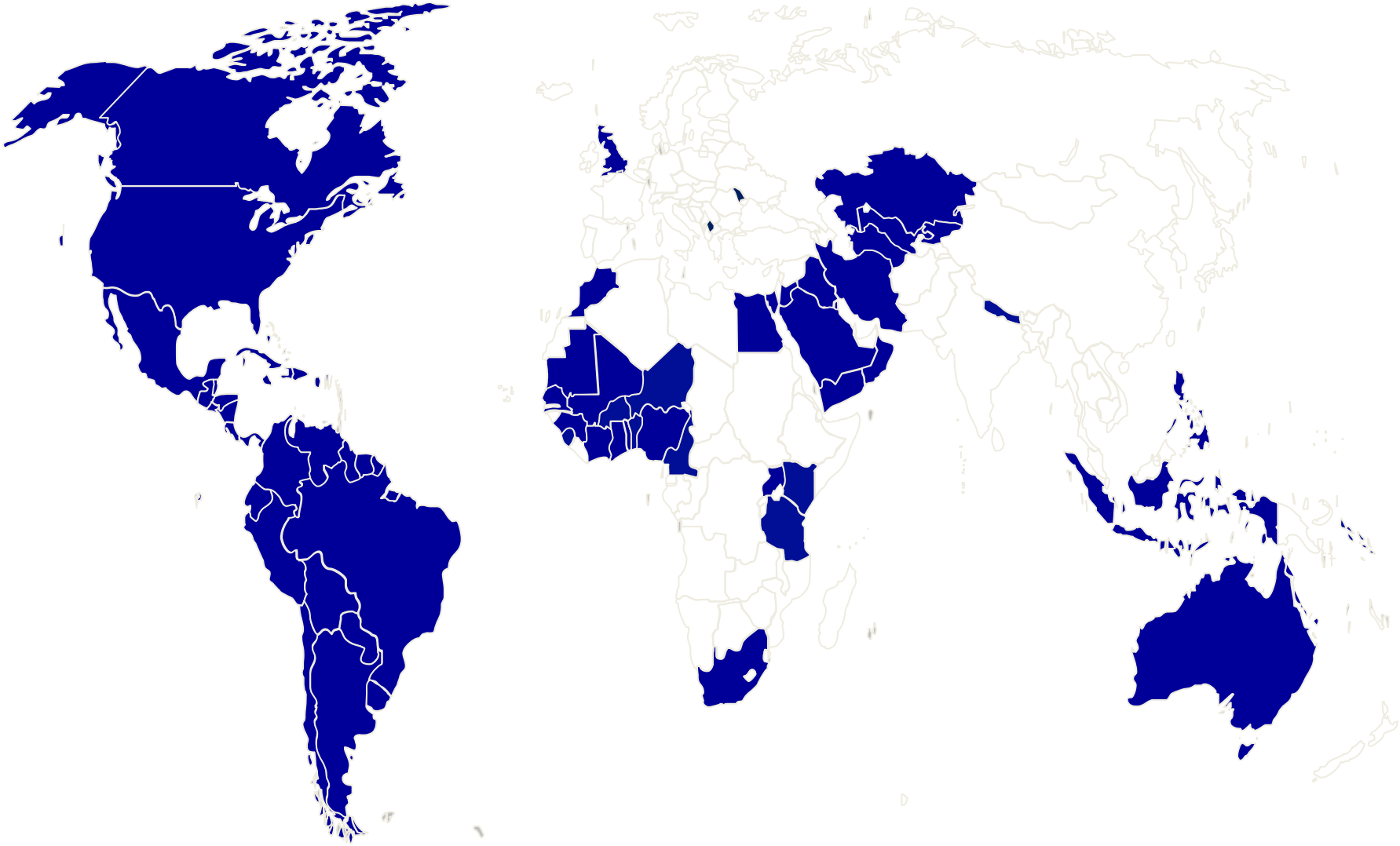
Flour Fortification Initiative
A Public-Private-Civic Investment in Each Nation

Wheat Flour Fortification Legislation

September 2013: 77 countries require iron and/or folic acid in wheat flour



All countries fortify flour with at least iron and folic acid except Australia which does not include iron, and Nigeria, Venezuela, the United Kingdom, and the Philippines which do not include folic acid.

2008 Workshop Recommendations

Nutrient	Type of flour (extraction)	Fortificant	Level of nutrient to be added (parts per million) By per capita wheat flour intake (g/day)			
			<75 g/day	75-149 g/day	150-300 g/day	>300 g/day
Iron	Low	NaFeEDTA Sulfate/Fumarate Electrolytic	40 60 NR	40 60 NR	20 30 60	15 20 40
	High	NaFeEDTA	40	40	20	15
Zinc	Low	Zinc Oxide	95	55	40	30
	High	Zinc Oxide	100	100	80	70
Folic Acid	Low or High	Folic Acid	5.0	2.6	1.3	1.0
Vitamin B12	Low or High	Cyancobalamin	0.04	0.02	0.01	0.008
Vitamin A	Low or High	Vitamin A palmitate	5.9	3.0	1.5	1.0

Recommendations on Wheat and Maize Flour Fortification Meeting Report: Interim Consensus Statement

http://www.who.int/nutrition/

Available in UN languages
English
Russian
Chinese

World Health Organization

Recommendations on Wheat and Maize Flour Fortification Meeting Report: Interim Consensus Statement

PURPOSE

This statement is based on scientific reviews prepared for a Flour Fortification Initiative (FFI) technical workshop held in Stone Mountain, GA, USA in 2008 where various organizations actively engaged in the prevention and control of vitamin and mineral deficiencies and various other relevant stakeholders met and discussed specific practical recommendations to guide flour fortification efforts being implemented in various countries by the public, private and civic sector. This joint statement reflects the position of the World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), The United Nations Children's Fund (UNICEF), Global Alliance for Improved Nutrition (GAIN), The Micronutrient Initiative (MI) and FFI. It is intended for a wide audience including food industry, scientists and governments involved in the design and implementation of flour fortification programs as public health interventions.

BACKGROUND

WHO and FAO published in 2006 the *Guidelines on Food Fortification with Micronutrients* (WHO/FAO, 2006). These general guidelines, written from a nutrition and public health perspective are a resource for governments and agencies implementing or considering food fortification and a source of information for scientists, technologists and the food industry. Some basic principles for effective fortification programs along with fortificants' physical characteristics, selection and use with specific food vehicles are described. Fortification of widely distributed and consumed foods has the potential to improve the nutritional status of a large proportion of the population, and neither requires changes in dietary patterns nor individual decision for compliance. Technological issues to food fortification need to be fully resolved especially with regards to appropriate levels of nutrients, stability of fortificant, nutrient interactions, physical properties and acceptability by consumers (WHO/FAO, 2006). Worldwide, more than 600 million metric tons of wheat and maize flours are milled annually by commercial roller mills and consumed as noodles, breads, pasta, and other flour products by people in many countries. Fortification of industrially processed wheat and maize flour, when appropriately implemented, is an effective, simple, and inexpensive strategy for supplying vitamins and minerals to the diets of large segments of the world's population. It is estimated that the proportion of industrial-scale wheat flour being fortified is 97% in the Americas, 31% in Africa, 44% in Eastern Mediterranean , 21% in South-East Asia , 6% in Europe, and 4% in the Western Pacific regions in 2007 (FFI, 2008).

THE FFI SECOND TECHNICAL WORKSHOP ON WHEAT FLOUR FORTIFICATION

Nearly 100 leading nutrition, pharmaceutical and cereal scientists and milling experts from the public and private sectors from around the world met on March 30 to April 3, 2008 in Stone Mountain, GA, USA to provide advice for countries considering national wheat and/or maize flour fortification. This *Second Technical Workshop on Wheat Flour Fortification: Practical Recommendations for National Application* was a follow up to a FFI, the US Centers for Disease Control and Prevention (CDC) and the Mexican Institute of Public Health, first technical workshop entitled "Wheat Flour Fortification: Current Knowledge and Practical Applications," held in Cuernavaca, Mexico in December 2004 (FFI, 2004). The purpose of this second workshop was to provide guidance on national fortification of wheat and maize flours, milled in industrial roller mills (i.e. >20 metric tons/day milling capacity), with iron, zinc, folic acid, vitamin B_{12} and vitamin A and to develop guidelines on formulations of premix based on common ranges of flour consumption. A secondary aim was to agree on the best practices guidelines for premix manufacturers and millers. Expert work groups prepared technical documents reviewing published efficacy and effectiveness studies as well as the form and levels of fortificants currently being added to flour in different countries. The full reviews will be published in a supplement of *Food and Nutrition Bulletin* in 2009 and the summary recommendations of this meeting can be found in http://www.sph.emory.edu/wheatflour/atlanta08/ (FFI, 2008).

RECOMMENDATIONS FOR WHEAT AND MAIZE FLOUR FORTIFICATION

Wheat and maize flour fortification is a preventive food-based approach to improve micronutrient status of populations over time that can be integrated with other interventions in the efforts to reduce vitamin and mineral deficiencies when identified as public health problems. However, fortification of other appropriate food vehicles with the same and/or other nutrients should also be considered when feasible. Wheat and maize flour fortification should be considered when industrially produced flour is regularly consumed by large population groups in a country. Wheat and maize flour fortification programmes could be expected to be most effective in achieving a public health impact if mandated at the national level and can help achieve international public health goals. Decisions about which nutrients to add and the appropriate amounts to add to fortify flour should be based on a series of factors including the nutritional needs and deficiencies of the population; the usual consumption profile of "fortifiable" flour (i.e. the total estimated amount of flour milled by

Suggested citation

WHO, FAO, UNICEF, GAIN, MI, & FFI. Recommendations on wheat and maize flour fortification. Meeting Report: Interim Consensus Statement. Geneva, World Health Organization, 2009 (http://www.who.int/nutrition/publications/micronutrients/wheat_maize_fort.pdf, accessed [date]).

Success of Fortifying with Iron

Country	Population studied	Improvement?
China	Women	Yes
Iran	Women and men	Yes
Venezuela	School-age children	Yes
Fiji	Women of child-bearing age	Yes
Azerbaijan	Preschool and school-age children	Yes
Kazakhstan	Preschool and school-age children	Yes
Mongolia	Preschool and school-age children	Yes
Tajikistan	Preschool and school-age children	Yes
South Africa	Women of child-bearing age	No
Uzbekistan	Preschool and school-age children	No

FFI review May 2013. See references on last slides.

Vitamin and Mineral Deficiency Contributes to:

- More than one-third of all ***deaths in children*** under the age of 5
- Stunting of an estimated ***195 million children*** under age 5 in developing countries
- Undeveloped ***cognitive capacity***, productivity and earning potential

istockphoto

Tracking Progress on Child and Maternal Nutrition. United Nation's Childrens Fund (UNICEF) November 2009 New York City

Iron Deficiency:

- Affects ***more people*** than any other health condition
- Reduces ***work capacity***
- Impairs a child's physical and ***intellectual development***
- Contributes to 20% of all ***maternal deaths***
- Is a leading cause of anemia which affects ***2 billion people*** – over 30% of the world's population

World Health Organization http://www.who.int/nutrition/topics/ida/en/index.html
Photo by Ivan Mateev at istockphoto

Micronutrients that can be added to flour

- **Vitamins**
  - **A,**
  - **B group (B1, B2, B3, B6, B12)**
  - **Folic Acid**
  - **D**
- **Minerals**
  - **Iron, Calcium, Selenium, Zinc**

Micronutrients for flour

- Minerals
  - Iron; Electrolytic, Ferrous Fumarate, Ferrous Sulphate, NaFeEDTA
  - Calcium; Calcium Carbonate or Sulphate
  - Magnesium; Magnesium Sulphate or Oxide
  - Phosphorus; Calcium Phosphate
  - Zinc; Zinc Sulphate or Oxide

Electrolytic Iron Specification

- Must USP/FCC grade, very fine particle size
- Assay
  - 96.0% Fe minimum
  - Particle Size Thru 200 mesh 99% min, Thru 325 mesh 95%
  - Arsenic 8ppm, Lead 25ppm, Mercury 5 ppm maximum for all above

Ferrous Sulphate

- Dried, Tan powder meeting USP/FCC grade
- Assay
  - As FeSO4 86-89% As Fe 31.6-32.6%
  - Particle size Thru 100 mesh 99.5%, Thru 200 mesh 90%
  - Arsenic 3 ppm, Lead 10 ppm, Mercury 3 ppm maximum for all above

Ferrous Fumarate

- Dried, Dark Tan powder meeting USP/FCC grade
- Assay
  - As FeFumarate 95-98% As Fe 31.6-32.6%
  - Particle size Thru 100 mesh 99.5%, Thru 200 mesh 90%
  - Arsenic 3 ppm, Lead 10 ppm, Mercury 3 ppm (maximum for all heavy metals above)

Sodium Iron EDTA

- Yellow Green Powder
- Assay
  - As EDTA 65.5-70.5%, As Iron 12.5-13.5%
  - Arsenic 1 ppm, Lead 1 ppm max
  - Particle Size Through 100 mesh 99.5%

- NOTE: Sodium Iron EDTA is recommended for high extraction wheat flour and any maize flour or maize meal

Properties of Iron Compounds

Iron source	Conc %Fe	Cost $/kg	Cost $kg Fe	Colour	Magnetic
Ferrous Sulphate	32	1.30	4.06	Tan	No
Ferric O. Phosph	29	2.50	7.81	Red	No
Iron, H Reduced	97	1.75	1.80	Black	Yes
Iron, E Reduced	98	4.00	4.10	Black	Yes
NaFe EDTA	13	6.00	46.15	Tan	No

Process Control in Flour Milling

- Flour milling needs process controls to ensure consistent quality and safety of the output: flour adequately milled to meet market requirements and safety standards.
- Effective process control systems use mechanisms to monitor activities and take timely corrective action.
- Well implemented process control gives an early warning of problems which in turn helps to avoid wastage, reworking of product, customer complaints, food recalls and liability issues etc.
- Good Process Control systems include multiple measurable parameters – they do not rely on just one parameter

QC/QA testing
Qualitative vs Quantitative

- QC/QA testing is used as just one of the tools available to the miller – used in conjunction with other process control tools
- Use of one parameter, flour additive or micronutrient as indicator for rapid qualitative/semi quantitative testing

Chemical Analysis of Micronutrients Quantitative Methods

- **Vitamins**
  - **HPLC, GC, Spectrophotometric, Colorimetric methods**
- **Minerals**
  - **Atomic Absorption Spectroscopy, Colorimetric and Spectrophotometric Methods**

NOTE: QUANTITATIVE METHODS MEASURE TOTAL LEVELS OF VITAMINS AND MINERALS i.e NATURAL AND ADDED LEVELS

Chemical Analysis of Micronutrients Qualitative Methods

- **Vitamin A**
  - **Colorimetric method for maize flour developed in South Africa**
- **Iron**
  - **Spot Test Method for added Iron in maize and wheat flours**

NOTE: Both methods measure **added** micronutrients but not Intrinsic iron in flour before fortification

Relative Costs of Chemical Assay (testing costs only)

- **Vitamins Analysis**
  - **Expensive: $25-50 per vitamin per sample and on different equipment**
  - **Assume 20 mills, one sample per week for 5 micronutrients at average price of $30 per sample – Total cost: $156,000 per year**
- **Mineral Analysis**
  - **Less Expensive: $15 per sample for Iron**
  - **Assume 20 mills one sample per week @ $15 per sample – Total cost: $15,600**

Use of Representative Micronutrient for Chemical Assay

- In flour fortification premixes are used containing vitamins and minerals (Iron)
- Iron is cheaper and more accurate to measure in flour than many vitamins
- Iron can be the representative micronutrient of the premix added to flour for chemical assay
- Iron can also be used in Spot Test for monitoring in the country AND as QC tool at the mill
- This system requires premix supplier to provide Certificate of Analysis (CoA) and importer to audit CoA

Iron Spot Test: Reagents

- Potassium Thiocyanate KSCN
- Hydrochloric Acid
- Hydrogen Peroxide

Iron Spot Test: Modification for Sodium Iron EDTA

- Add the 50/50 solution of Potassium Thiocyanate (KSCN) 10% solution W/V and Hydrochloric Acid 2N solution V/V onto the flour slick
- Allow the spots to develop over 2 minutes and compare to standard.
- Omit the use Hydrogen Peroxide solution

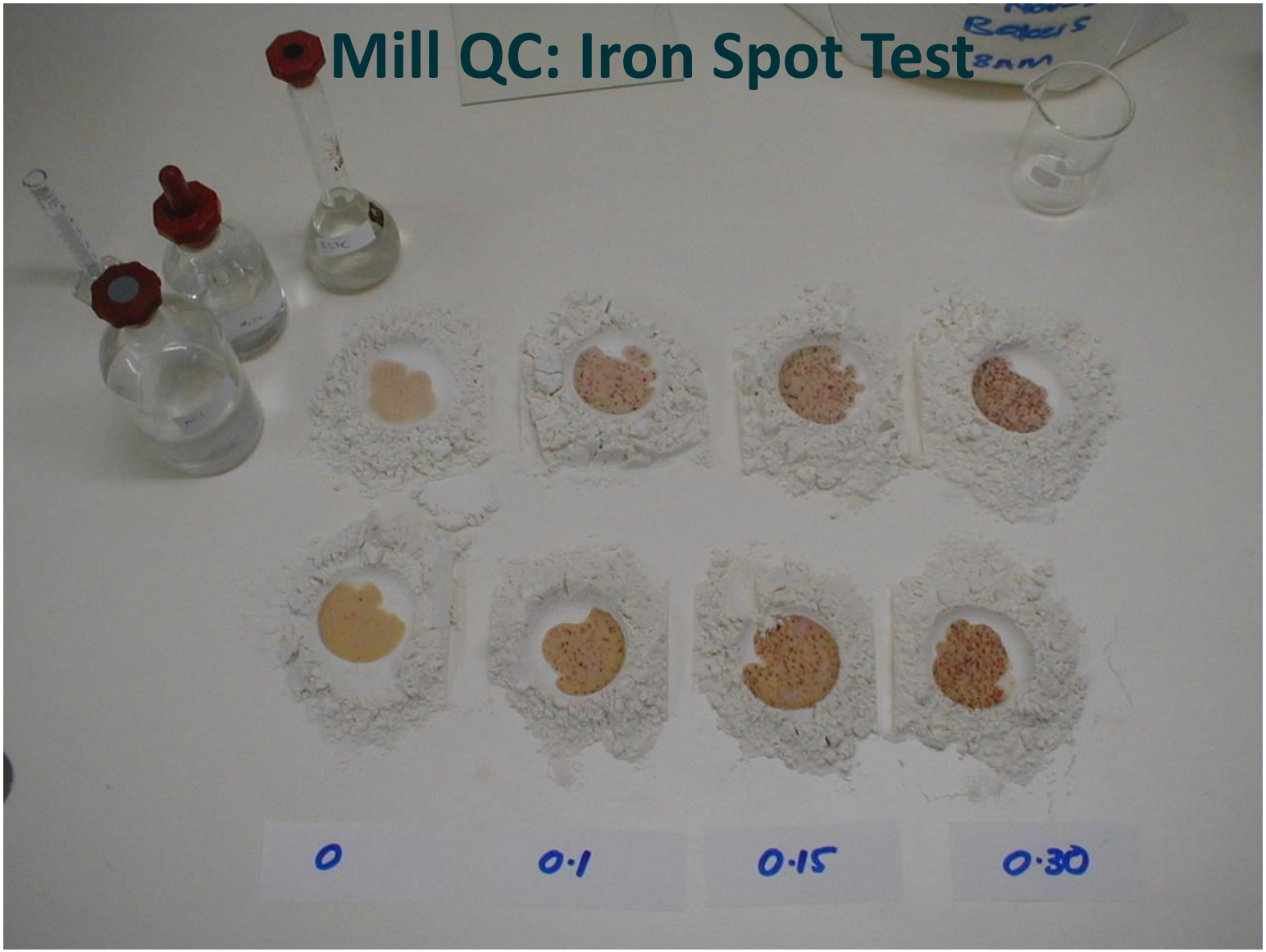
Iron Spot Test: Additional points

- When comparing samples to standards the same type of iron compound MUST used in both the sample and the standard i.e. $FeSO_4$ for $FeSO_4$ or Electrolytic Fe for Electrolytic Fe and NaFeEDTA standard for NaFeEDTA
- Do not use $FeSO_4$ standard to evaluate flour fortified with Electrolytic Fe
- Differences due to compound type and particle size.

Mill QC: Iron Spot Test

Iron Spot Test for added premix in flour

Mill QC: Iron Spot Test



Recent Developments

- Millers Fortification Toolkit Updated
  - Additional information and video clips based on new technologies, feeders, QC tests
  - Was be posted on line in March 2013
- Iron Spot Test modified for NaFeEDTA
  - Official AACC method did not detect NaFeEDTA
  - Test modified to detect NaFeEDTA – simple modification
- iCheck hand held device can measure Iron as NaFeEDTA quantitatively

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Thank you for your kind attention!

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