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Guidelines for Iron Fortification of Cereal Food Staples

SUSTAIN wishes to acknowledge and thank the following people for their assistance in the preparation and review of these guidelines:

Peter Ranum, MS; Sean Lynch, MD; Thomas Bothwell, MD, DSc; Leif Hallberg, MD, PhD; Richard Hurrell, PhD; Paul Whittaker, PhD; Jorge L. Rosado, PhD; Lena Davidsson, DrMedSc; Venkatesh Mannar, MS; Tomas Walter, MD; Susan Fairweather-Tait, PhD, DSc; Omar Dary, PhD; Juan Rivera, PhD; and Leticia Bravo, MS

www.sustaintech.org

March 2001

Guidelines for Iron Fortification of Cereal Food Staples

The following are recommended guidelines for the type and levels of iron to add to cereal food staples.[1] These guidelines stem in part from recommendations made at a workshop in Monterrey, Mexico that was convened by SUSTAIN to help resolve outstanding questions related to the bioavailability of elemental iron powders in cereal fortification.[2] These guidelines are based on over fifty years experience with iron enrichment of cereals and current knowledge of iron fortificants. They have been written with the goal of optimizing bioavailability, cost-effectiveness, and consumer acceptance of the fortified product, and have been reviewed and endorsed by a panel of experts in the field. However, it is important to note that these guidelines should only be considered interim and may change as more information becomes available on the bioavailability of elemental iron powders, which are the most commonly used iron fortificants worldwide.

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1. This covers flour made from wheat and corn and foods made from these grains, including those from wheat (bread, biscuits, pasta, noodles), maize (corn meal, masa flour, arepa flour, tortillas) rice, and sorghum. These guidelines are not designed for other food products such as those formulated for special dietary needs (i.e. complementary and infant foods) or high-value products (i.e. ready-to-eat cereals), which are not considered food staples.

2. Recommendations from the September 2000 Monterrey Workshop, together with a review of research conducted to-date on elemental iron powders will be published in 2001. For more information on SUSTAIN (Sharing U.S. Technology to Aid in the Improvement of Nutrition), please visit our website at: http://www.sustaintech.org

Because of its high bioavailability and low cost, FCC grade dried ferrous sulfate is often the best iron source.

Selection of Iron Fortificant:

- Fortification of milled, refined cereals is a convenient way to deliver iron and other micronutrients to a general population whose diets are deficient in those micronutrients. Iron should be included in cereal fortification or enrichment programs in countries where iron deficiency anemia is prevalent.

- Because of its high bioavailability and low cost, FCC[4] grade dried ***ferrous sulfate*** is often the best iron source. It can be used in bakery flour[5], semolina[6], and other types of low extraction[7] wheat flours, which are normally used within one to two months after production.[8] The ferrous sulfate should be a fine particle size, dried material. Large particle size or hydrated[9] ferrous sulfate can cause color and spotting problems and so are not recommended.

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4. Food Chemicals Codex, Vol. IV
5. Bakery flour is typically used within a month after milling.
6. Or any type of wheat flour used to produce pasta (such as noodles, macaroni and spaghetti products).
7. The "extraction rate" is the flour yield or the percentage of flour extracted from wheat. Ferrous sulfate is more likely to cause storage and sensory problems in high extraction "brown" flours, or extraction rates above 82%, than in low extraction (72-78%) "white" flours, because of their higher unsaturated fat content
8. The use of ferrous sulfate may not be appropriate in products stored for extended periods due to its promotion of oxidative rancidity of native or added fats, which reduces acceptable shelf-life. It can also produce changes in color and flavor over time, which would reduce consumer acceptance. Ferrous sulfate is not recommended for flour used in mixes with added fat, home-use all-purpose flour requiring an extended shelf life of over three months, and flour used in instant or Japanese noodles.
9. Hydrated ferrous sulfate is a highly soluble, blue or blue-green powder with approximately 7 waters of hydration. Dried ferrous sulfate is a beige or light tan powder with about one water of hydration.

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- FCC grade ***ferrous fumarate*** is another good choice because it has a bioavailability similar to that of ferrous sulfate. It is insoluble in water and therefore causes fewer organoleptic problems than the more soluble ferrous sulfate. However, it is typically more costly than ferrous sulfate.

- ***Elemental iron powders***[10] may be considered as potential iron sources if unacceptable changes in color, flavor or storage properties of the fortified food prevent the use of either ferrous sulfate or ferrous fumarate, as is often the case.[11]

- Based on current information relating to potential bioavailability of elemental iron powders, there are two products that may be considered for addition to cereals: electrolytic iron and hydrogen reduced iron. Both powders should be FCC grade with a 325 (<45 microns) mesh size.

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10. Elemental iron powders differ in the method of production. Methods in use today are reduction by hydrogen, reduction by carbon monoxide, electrodeposition, decomposition of iron pentacarbonyl and water atomization. All of these substances except for atomized iron are affirmed Generally Recognized as Safe (GRAS) under the U.S. Code of Federal Regulations (U.S. Food and Drug Administration) [21CFR184.1375(a)]. According to 21CFR184.1375(a)(1) and FCC specifications, only hydrogen reduced and carbon monoxide reduced irons are classified as “Reduced Iron”. For more information on the production methods for atomized iron or other iron powders, consult: The Handbook of Powder Metal Technologies and Applications, Vol. 7, American Society of Metals, 1998.

11. Some countries, like Canada, which enriches all flour at the mill, rely mainly on elemental iron powders. The United States uses both ferrous sulfate (primarily for bakery flour, semolina or pasta flour) and elemental iron powder, with the latter being the most common. Venezuela uses a combination of both ferrous fumarate and elemental iron powder.

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- ***Electrolytic iron*** appears to be the best choice of the elemental iron powders at the current state of our knowledge, since studies carried out between 1970 and 1990 provide the most consistent and reliable information about bioavailability of this iron powder. Electrolytic iron is approximately half as bioavailable as ferrous sulfate. The electrolytic iron used should have physical properties and dendrite structure identical to the product formerly supplied under the trade name Glidden A131.[12]

- If electrolytic iron is not available at a reasonable cost, ***hydrogen reduced iron*** could be considered, even though experimental information indicating adequate bioavailability of hydrogen reduced iron is much less consistent than that for electrolytic iron. It is recommended that the 325 mesh (<45 microns) be used rather than 100 mesh as specified in the current FCC guidelines.[13]

- At the present time, there is insufficient information about the bioavailability of elemental iron powders produced by carbon monoxide reduction or by water atomization to recommend their use.[14] Carbonyl iron is not recommended because of its questionable bioavailability in one human study and higher cost.

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12. This product is now manufactured by the OMG Americas Company.

13. Hydrogen reduced iron is manufacturing by the Pyron Division of Höganäs AB.

14. Food-grade atomized iron is manufactured by Quebec Metal Powders and carbon monoxide reduced iron is manufactured by Höganäs AB.

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- Because the impact of fortifying foods that contain high levels of inhibitory factors (phytic acid or polyphenols) can be expected to be limited, fortification should be considered as only one of several strategies including: modifying or diversifying the diet; adding an enhancer of iron absorption; reducing the content of inhibitors; adding the fortification iron to a vehicle that is consumed separately from the main inhibitory meals, and providing iron supplements.[15]

- Where high phytic acid or polyphenol levels significantly reduce iron absorption and where their use is permitted, sodium iron-EDTA or disodium EDTA plus ferrous sulfate[16] should be considered.

Determining Addition Level:

- In planning a fortification strategy, the optimal level of iron fortification will depend on a number of factors, including the prevalence of iron deficiency, the nature of the diet, the distribution of cereal foods, and the bioavailability of the added iron.[17]

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15. For more information on iron fortification see: Hurrell, R. *The Mineral Fortification of Foods*, ISBN 0 905 748 32 8, Leatherhead Intn. Ltd., 1999; Hurrell, R. "Preventing Iron Deficiency through Food Fortification", Nutr Rev 55: 210-220, 1997; Clydesdale, F. M. and Wiemer, K. L. *Iron Fortification of Foods.* Academic Press, NY. 1985; Allen, L. H. and Ahluwalia, N. *Improving Iron Status through Diet.* OMNI, Washington D.C. June 1997.

16. Research has demonstrated that the addition of disodium EDTA to ferrous sulfate can enhance iron absorption in cereal products; however, no information is currently available to indicate whether disodium EDTA would have an enhancing affect with other iron compounds.

17. Some countries may wish to consider the iron fortification standards used by neighboring countries in order to avoid any problems with the free trade of fortified commodities.

The actual enrichment is accomplished with a vitamin/ mineral premix formulated to meet the specified enrichment standards.

- The minimum addition level recommended to restore the iron present in the whole grain product is 25 ppm iron for white flour using ferrous sulfate or ferrous fumarate. This would give an iron level in the enriched flour of about 35 ppm, or equivalent to the original level found in a whole-wheat flour.

- Higher iron addition levels may be necessary in countries with low flour consumption where iron deficiency is prevalent.

- Because of the lower bioavailability of elemental iron powders compared to soluble iron salts, the addition rate of an elemental iron powder should be twice that of iron from the iron salts. For example, add 50 ppm iron as electrolytic iron in place of adding 25 ppm from ferrous sulfate.[18]

- Iron enrichment of flour is generally regulated in most countries by specifying a minimum iron level in the enriched flour, which would include both the added and native iron, rather than specifying the exact quantity of iron fortificant to add.

- In most cases iron is added along with other micronutrients. The actual enrichment is accomplished with a vitamin/mineral premix formulated to meet the specified enrichment standards. The types of vitamins in the premix, not the iron, determine the shelf life of the premix because most iron fortificants are more stable than the vitamins.

Conclusion: It is important to note the limitations of data related to the bioavailability of elemental iron powders. These guidelines are based on the best information currently available and may be subject to modification as more complete information on the bioavailability of iron compounds becomes available. Given the high prevalence of iron deficiency anemia in developing countries, and the wide use of elemental iron powders in food fortification programs, a thorough evaluation of these powders is highly recommended.

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18. The maximum level of iron that can be added to milled cereals without causing quality problems in the final food product will vary with the type of product and should be tested. Iron addition levels up to 40 ppm from ferrous sulfate and 60 ppm from elemental iron powders have been successfully used in wheat flour, but certain white maize meals may not tolerate as much iron due to concerns with color.