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Guidelines for Iron Fortification of Cereal Food Staples

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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) and rice. 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[3] grade dried ***ferrous sulfate*** is often the best iron source. It can be used in bakery flour[4], semolina[5], and other types of low extraction[6] wheat flours, which are normally used within one to two months after production.[7] The ferrous sulfate should be a fine particle size, dried material. Large particle size or hydrated[8] ferrous sulfate can cause color and spotting problems and so are not recommended.

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3. Food Chemicals Codex, Vol. IV

4. Bakery flour is typically used within a month after milling.

5. Or any type of wheat flour used to produce pasta (such as noodles, macaroni and spaghetti products).

6. 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

7. 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.

8. 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.

FCC grade ferrous fumarate is another good choice because it has a bioavailability similar to that of ferrous sulfate.

- 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***[9] 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.[10]

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9. Elemental iron powders are manufactured through several different methods of production, with each yielding a product that has distinct physical properties. The Food Chemicals Codex (FCC) provides specifications for the following iron powders: Carbonyl Iron, Electrolytic Iron, and Reduced Iron. The U.S. Code of Federal Regulations, under Title 21 — Food and Drug Administration [21CFR184.1375(a)], describes Elemental Iron as "metallic iron obtained by any of the following processes: reduced iron, electrolytic iron, and carbonyl iron." The U.S. Code further describes reduced iron as that which is "prepared by reacting ground ferric oxide with hydrogen or carbon monoxide at an elevated temperature." For more information on these as well as other production methods for iron powders, consult: The Handbook of Powder Metal Technologies and Applications, Vol. 7, American Society of Metals, 1998.

10. Some countries, like Canada, which enrich 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 in corn flour and ferrous fumarate in wheat flour.

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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.

- If electrolytic iron is not available at a reasonable cost, another type of elemental iron powder may need to be considered. However, at the present time, there is insufficient information about the bioavailability of the other elemental iron powders to offer specific recommendations. Whatever type of elemental iron powder is selected, it is recommended that the 325 mesh (<45 microns) be used rather than 100 mesh as specified for reduced iron in the current FCC guidelines.

- 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.[11]

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11. 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.

Whatever type of elemental iron powder is selected, it is recommended that the 325 mesh (<45 microns) be used.

- Where high phytic acid levels significantly reduce iron absorption and where their use is permitted, sodium iron-EDTA or disodium EDTA plus ferrous sulfate[12] 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.[13]

- 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.

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12. 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 effect with other iron compounds.

13. 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 addition rate of an elemental iron powder should be twice that of iron from the iron salts.

- 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.[14]

- 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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14. 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.