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Monterrey Workshop Summary: Evaluating the Usefulness of Elemental Iron Powders

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Iron deficiency anemia (IDA) is one of the most prevalent public health problems in the developing world, with women and children especially affected. The World Health Organization estimates that approximately 50% of children, 42% of women, and 26% of men are affected in developing countries.[1] IDA is a significant challenge in developing countries because their diets consist mainly of cereal products that have relatively low levels of absorbable iron. This results, in part, from plant components such as phytates and polyphenols that inhibit iron absorption.

Despite the magnitude of IDA, little is known about the extent to which iron powders commonly used as food fortificants are absorbed by the body. Elemental iron powders are the most common iron fortificant used worldwide because they cause the fewest problems with color, flavor, and rancidity in food products and are relatively inexpensive. However, research studies conducted over the last 45 years have produced highly variable results with respect to the bioavailability of these powders (from 5% to 145% relative to ferrous sulfate). Consequently, questions about the varying bioavailability of elemental iron have hindered implementation of cereal enrichment programs worldwide. This came to SUSTAIN's attention as they began assisting Mexico with the fortification of corn masa flour.

To help resolve questions about the bioavailability of elemental iron powders, SUSTAIN convened a panel of world-renowned research scientists, physicians, and industry specialists to review past research. The meeting was held in Monterrey Mexico in September 2000 at the Monterrey Institute of Technology. During the course of the meeting, it became apparent that there was significant confusion about the precise type of iron powder used in past studies and in current enrichment programs.* In some cases, fortification companies failed to correctly identify iron powders supplied. In other cases, researchers failed to supply complete and accurate information on iron powders used in research, thus making it difficult to draw conclusions from some studies. Nevertheless, based on a review of available data, workshop participants concluded that certain powders should not be recommended for use in fortification programs, whereas others had merit but required further study. Moreover, scientists and industry agreed on the need to work together to identify the most appropriate of these powders for use in fortification programs. Key findings and recommendations resulting from the Monterrey meeting follow.

- Electrolytic iron (325 mesh) appears to be the best choice of the elemental iron powders based on our current knowledge because 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.† At the present time, however, there

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* 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 provides specifications for the following iron powders: carbonyl iron, electrolytic iron, and reduced iron. The US Code of Federal Regulations, under Title 21—Food and Drug Administration [21CFR184.1375(s)]—describes elemental iron as "metallic iron obtained by any of the following processes: reduced iron, electrolytic iron and carbonyl iron." The US Code further describes reduced iron as that which is "prepared by reacting ground ferric oxide with hydrogen or carbon monoxide at an elevated temperature."[2]

† Three distinct families of elemental iron powders have historically been used in food fortifications. These are hydrogen reduced (Pyron, USA) and carbon monoxide reduced Höganäs, Sweden) "sponge" iron, electrolytic iron (OMG Americas, USA), and carbonyl iron (ISP and BASF). More recently, iron powder products manufactured by Quebec Metal Products (Canada)

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 Food Chemicals Codex guidelines.

- Experimental evidence suggests that the bioavailability of iron powders could be enhanced with improved production technology, but the commercial feasibility of such technologies is not known.
- Current commercial iron powders must be evaluated using established methodology to determine what their bioavailability actually is.
- The results of these bioavailability studies should be used to develop a simple analytic screening test to standardize commercial iron powders in terms of bioavailability characteristics.
- Because the impact of fortifying foods that contain high levels of inhibitory factors (phytic acid or polyphenols) may be limited, fortification should be considered as only one of several strategies. 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.
- 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 iron powders in current use is highly recommended.

These findings and recommendations, together with a detailed review of studies conducted to date on elemental iron powders will be published by SUSTAIN in a peer-reviewed journal later in the year.[2] This review, which was principally authored by Richard Hurrell, provides a detailed review of studies conducted over the last 45 years on elemental iron powders as well as a summary of the key findings and recommendations from the Monterrey Workshop. It was commissioned by SUSTAIN in preparation for the workshop and will be submitted later this month for publication in *Nutrition Reviews.*

SUSTAIN will also be publishing simple, easy-to-use *Guidelines for Iron Fortification of Cereal Food Staples.*[3] These guidelines provide recommendations on the type and levels of iron to add to cereal food staples. They are based on the best information currently available and will be subject to modification as more complete information on the bioavailability of iron compounds becomes available. They have been prepared and reviewed by leading experts in iron metabolism and fortification in collaboration with SUSTAIN. They stem in part from recommendations made at the Monterrey Workshop in September 2000, and were prepared and endorsed by leading public and private sector experts in iron metabolism and fortification. Whereas they represent the best information currently available, these guidelines should only be considered interim and may change as more complete information on the bioavailability of iron compounds becomes available.

To address concerns about the bioavailability of elemental iron powders, SUSTAIN has launched a comprehensive evaluation of each of the iron powder fortificants in use today. Initially, each of the iron powders will be evaluated through a series of screening tests. The most promising iron powders will then be evaluated in a human trial to be carried out in mildly iron-deficient volunteers. Results from the complete series of studies will be released as they are completed. Initial results from the screening studies will be available in 2002 and results from the human study are expected in 2003. This work is being conducted with broad participation from industry and the scientific community. The outcome from these studies will provide the basis for making recommendations on the use of elemental iron powders in food fortification programs worldwide. In addition, it is hoped that this review will also provide a basis for manufacturers to improve the bioavailability characteristics of their iron powder products. This is expected to accelerate the adoption of food fortification with iron and have far-reaching effects on people suffering worldwide from the debilitating consequences of iron deficiency anemia.

1. Prevention of micronutrient deficiencies: tools for policymakers and public health workers. Washington, DC: IOM, 1998
2. Hurrell R, Bothwell T, Lynch S, et al. The usefulness of elemental iron for cereal flour fortification: a SUSTAIN Task Force Report.
3. SUSTAIN Task Force. Guidelines for iron fortification of cereal food staples. Nutriview 2001;3:2–3

and Industrial Metal Powders (India) have been made available for food fortification. Elemental iron powders are sold in a variety of different grades, based on the grinding and sieving procedures employed and the resulting particle size distribution.