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## In memoriam:

## Guillermo Arroyave, the father of sugar fortification

Guillermo (Willy) Arroyave is with us no more. He passed away unexpectedly at his home in San Diego, California, on August 17, 2008, aged 86, leaving family, friends and colleagues around the world, whose lives and careers have been influenced by his congenial temperament and perseverance, with a heavy heart.

Dr Arroyave is best known for his work on the fortification of sugar with vitamin A. This has played a decisive role in controlling vitamin A deficiency in Central America, and helped to ensure the survival and improve the health of countless children in the region. Since 1989, Guatemala is the model for using sugar fortification as an effective public health measure. Currently, sugar is fortified with vitamin A in Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, Zambia and Nigeria, and many other countries are planning to do so. Dr Arroyave also established, in 1955, that iodate is more stable than iodide as a salt fortificant. This has had important practical implications for the control of iodine deficiency disorders worldwide.

Born in Guatemala in 1922, Guillermo Arroyave graduated from the national San Carlos University of Guatemala with a degree in pharmacy in 1947, and received a master's degree in nutrition and food sciences at the Massachusetts Institute of Technology in 1948. In 1949, Dr Nevin Scrimshaw took him on the staff of the newly founded Institute of Nutrition of Central America and Panama (INCAP), as one of its first professionals. In 1950, he traveled to the University of Rochester to further his academic and technical development, obtained his PhD degree, and met his future wife, Connie. After returning to Guatemala in 1953, Willy continued his career at INCAP until 1982, when he and his wife returned to the USA,

first to Stanford, then to San Diego. Throughout his working life, he authored or coauthored numerous publications and technical reports in Spanish and in English; his contributions to nutritional knowledge were immense and immeasurable.

Willy was a pioneer in the application of nutritional biochemistry to the deficiency problems of Central and Latin America in the areas of iodine, vitamin A, protein and specific amino acids. He was president of the Latin American Nutrition Society (1975–76), and a charter member of the International Vitamin A Consultative Group (IVACG). He was a recipient of Guatemala's highest national citizenship award, the Order of the Quetzal. He was also awarded the national order "Rodolfo Flores" for achievements in public health, and received other recognitions from UNICEF, PAHO, INCAP, the National Committee of Blind and Deaf, and the National University of Guatemala. He was a member of the Directive Council of the Academy of Science of Guatemala (1960–63), and an honorary member of the American Institute of Nutrition, which honored him with the Conrad A. Elvehjem award. In 1997, he was co-recipient of the Prince Mahidol award for his contribution to international public health, receiving the medal from King Bhumipol IX of Thailand.

Willy Arroyave did not confine science to the laboratory bench, and was clearly one of the pillars on which the golden age of nutrition and food technology in Latin America was built. As teacher and mentor, he certainly influenced our own careers profoundly, and we have much to thank him for. His legacy will probably touch the lives and daily efforts of nutrition and public health workers worldwide.



Noel Solomons  
and Omar Dary

## Editorial:

## A worthwhile investment

According to Maslow's theory, published in 1943, obtaining adequate food is one of an individual's most important basic physiological needs, in third place after having air to breathe and water to drink. Hunger can control a person's every thought, leading to frustration, apathy and weakness. Without food, people have no interest in needs higher up the pyramid, such as safety, social and esteem needs.

Today, eating has a high priority not only for the people at the base of Maslow's pyramid. The provision of adequate nutrition has become a matter of concern

for governments, aid organizations, food producers, nutrition scientists and economists all over the world. It is being increasingly recognized that a hungry population is a serious burden for any nation and for world peace. A lack of nutrients increases morbidity and mortality, and impairs mental and physical development, leading to significant losses in productivity and income. Recent uprisings in response to escalating food prices show how urgent the fight against hunger and malnutrition has become.

In June this year, heads of state and government,

ministers and representatives of 180 countries and the European Community attending a high-level conference in Rome, declared their determination to seek ways of achieving world food security, and address challenges of higher food prices, climate change and bioenergy. FAO Director-General Jacques Diouf called for immediate action and appropriate resources, saying that the time for talking is long past.

At a meeting in Copenhagen at the end of May, some of the world's leading economists also agreed that efforts to reduce micronutrient malnutrition are among the best investments for improving the state

of the planet. The chosen options have a cost-benefit ratio between 1:8 and 1:30.

Because of soaring food prices, poor people have even less choices in their diet. They have to buy the cheapest foods they can find, and eat less. Reliance on high-calorie, non-fortified, starchy staple foods, rather than nutrient-rich alternatives such as meat, fish, dairy, fruit and vegetables, aggravates the problems of micronutrient deficiency. This situation raises the challenge once more for governments to consider staple food fortification as a possible solution.

A. Bowley

## Conference report:

# World leaders renew commitment to eliminate hunger

More than 5000 people from 181 countries (including 43 heads of state or government and 100 high-level ministers) attended the High-Level Conference on World Food Security and the Challenges of Climate Change and Bioenergy, convened by the Food and Agriculture Organization of the United Nations in cooperation with the Consultative Group on International Agricultural Research, the International Fund for Agricultural Development and the World Food Programme, and held at the FAO Headquarters in Rome on 3–5 June 2008.

The meeting concluded with the adoption by acclamation of a declaration calling on the international community to increase assistance for the world's most vulnerable countries and populations. In adopting this declaration, the participants pledged to embrace food security as a matter of permanent national policy, and renewed their commitment to achieving the Millennium Development Goals.

As a first line of action, the declaration calls on the relevant UN agencies and other involved organizations to respond urgently to requests for assistance from affected countries. The next proposed measure is to provide immediate support for agricultural production and trade. While accepting that there is an urgent need to address the consequences of soaring food prices, the declaration stresses that it is also essential to introduce effective medium- and long-term measures to establish sustainable agricultural systems, and create economic opportunities for smallholder farmers and fishers in developing countries.

In his opening speech, FAO Director-General Jacques Diouf announced: "What is important today is to realize that the time for talking is long past. Now is the time for action." In the final document, the participants state: "We firmly resolve to use all means to alleviate the suffering caused by the current crisis, to stimulate food production and to increase investment

## Responding to nutrition threats

A background paper prepared for the summit meeting by teams from FAO and the International Food Policy Research Institute (IFPRI) examines the consequences of climate change and rising bioenergy demand for sustainable development, food security and nutrition throughout the life cycle [1]. Adverse effects related to the increased incidence and severity of heat waves, flooding, fire and drought are likely to affect the health and nutritional status of millions of people. Increased water scarcity reduces food supply. Rising demand for biofuels from food crops drives up commodity and food prices. As a result, poor people have lower food and micronutrient intakes. Deforestation, agriculture and livestock production further accelerate climate change and land degradation.

Although global leaders have repeatedly pledged to take action to decrease malnutrition over the past twelve years, progress has been unacceptably slow. Governments need to prioritize nutrition efforts, and provide adequate resources. Programs should include the following harmonized steps:

- Create an enabling environment to promote peace, eradicate poverty, and remove gender inequality.
- Promote a fair and market-oriented world trade system.
- Increase investments in human resources, sustainable food production and rural development.
- Implement policies to improve access to sufficient safe and wholesome food.
- Focus on participatory and sustainable agriculture.
- Direct actions to improve household food security, food quality and safety; control infectious diseases and micronutrient deficiencies; promote breast feeding and healthy life styles; care for the vulnerable; introduce productive safety nets; provide direct assistance.
- Prevent/prepare for emergencies.
- Build anti-hunger alliances.

The first Millennium Development Goal, to halve hunger by 2015, can still be realized, say the authors. However, developing countries must gear up efforts to revitalize agricultural and rural development to ensure that hungry people have access to food, and donors must fulfill their pledges to increase development assistance substantially. Good nutrition makes an essential contribution to the fight against poverty. It protects and promotes health, reduces mortality, enables children to attend and benefit from school, and enhances adult productivity and income.

1. Cohen MJ, Tirado C, Aberman N-L, Thompson B. *Impact of climate change and bioenergy on nutrition*. FAO/IFPRI 2008. Available at: [http://www.fao.org/ag/agn/index\\_en.stm](http://www.fao.org/ag/agn/index_en.stm)

in agriculture, to address obstacles to food access and to use the planet's resources sustainably, for present and future generations.”

### Actions taken

Although the summit was not a pledging conference, a number of donors present announced firm financial contributions; others indicated they had increased or would increase the level of their financing. The money will benefit countries affected by the current world food crisis, allowing them to grow enough food for themselves in the coming planting seasons, and helping them to achieve continuing food security through investment in agriculture and research. This new financing brings global commitment to food security and agriculture this year to US\$18.36 billion. According to Dr Diouf, it would take only US\$30 billion a year to eradicate hunger in the world—a small amount in relation to military spending, for example.

Also during the summit, the Alliance for a Green Revolution in Africa (AGRA), the FAO, the International Fund for Agricultural Development, and the World Food Programme signed a memorandum of understanding. The partnership aims to significantly boost food production in Africa's 'breadbasket' regions (areas with relatively good rainfall, soil, infrastructure and markets), link local food production to food needs, and create opportunities for smallholder farmers. “This



*Photo on title page: Press conference with UN Secretary-General Ban Ki-moon and Heads of FAO, IFAD, WFP and the World Bank. High-Level Conference on World Food Security: the Challenges of Climate Change and Bioenergy. Food and Agriculture Organization of the United Nations (FAO), Rome, 3-5 June 2008.*

collaborative initiative is part of AGRA's strategic vision to build partnerships that pool the strengths and resources of the public and private sectors, civil society, farmers organizations, donors, scientists and entrepreneurs across the agricultural value chain,” said AGRA Chairman Kofi Annan. To spur a green revolution that respects Africa's regions and biodiversity, AGRA will develop and promote higher yielding, locally adapted seeds, soil fertility options, water management systems and markets.

Extracted from FAO press releases and conference brochure. For more information, see: <http://www.fao.org/foodclimate/hlc-home/en/>

## Conference report:

# Copenhagen Consensus: Micronutrients are best buy

During the last week of May 2008, an expert panel of eight respected economists, including five Nobel Laureates, met in Copenhagen, Denmark, to assess research done over the past two years by more than fifty of their colleagues. Projects investigated the costs and benefits of solutions to ten of the world's biggest challenges: Malnutrition and hunger, conflicts, air pollution, diseases, terrorism, subsidies and trade barriers, women and development, sanitation and water, education and global warming.

Organizer and founder of the project, Bjørn Lomborg, expressed gratitude to the members of the panel for taking a full week out of their busy schedules to devote themselves to answering the tough question: If you had an extra \$75 billion to do good in the world, where would you spend it? “It's not very often you get five Nobel laureates being locked up in the same room for four days, talking about the biggest world issues, and I hope that the dedication they've put into compiling this unique overview of the best spending options to improve the world will resonate with decision-makers all over the world.”

### Nutrition first and third on list

Top of the list of the best spending options to improve the world is micronutrient supplementation for the 140 million undernourished children in developing countries. According to the analysis by economist Sue Horten of Wilfrid Laurier University, Canada, providing vitamin A and zinc supplements for 80% of them would cost just \$60 million annually, but bring a benefit of more than \$1 billion. This means that each dollar spent can bring improvements in health and future earnings worth more than \$17. Interventions comprise two doses of vitamin A and two courses of zinc annually in children aged 6–24 months in sub-Saharan Africa and South Asia. According to UNICEF, current coverage in both regions is about 70% with vitamin A, and essentially zero with zinc.

Douglass C. North, member of the expert panel and Nobel laureate in economics, explained that this project: “has immediate and important consequences for improving the wellbeing of poor people around the world—that is why it should be our number-one priority.”

The panel identified ratification of the Doha trade reforms (named after the 2001 declaration of the Ministerial Conference in Doha, Qatar, that provides a mandate for negotiations on global trade) in second place. This would yield exceptionally large benefits for a comparatively modest investment. [The latest negotiations in Geneva collapsed on 29 July 2008 despite encouraging progress: Editor].

Third on the priority list of the economic experts is salt iodization and fortification of staple foods with iron. An estimated two billion individuals worldwide (more than half in South Asia) suffer from iron deficiency. A third of households in developing countries do not consume iodized salt, which protects against mental retardation.

Iron fortification and salt iodization offer considerable benefits for a relatively small cost. Salt iodization in the three lagging regions (currently 64% in South Asia, 64% in sub-Saharan Africa, and 50% in Central and Eastern Europe and the Commonwealth of Independent States) can be scaled up for an annual investment of \$19 million. The benefits will be in the order of \$570 million (more than \$30 for each dollar spent). Iron fortification for 80% of the population in South Asia and sub-Saharan Africa (where current coverage is assumed to be negligible) can be scaled up for an annual investment of \$267 million. The benefits will be in the order of \$2.1 billion (about \$8 for each dollar spent).

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*Copenhagen Consensus: Providing essential micronutrients to 80% of the world's hungry would cost only \$347 million a year, but provide benefits worth more than \$5 billion in reduced healthcare spending and increased future earnings*

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“It’s hard to see how one could do any better in terms of coming up with a well-founded list of where to start for the purpose of betterment of the dire conditions in much of the world,” said member of the expert panel and Nobel laureate in economics, Finn E. Kydland. He noted that the Copenhagen Consensus: “identifies experts in each area who propose solutions justified in



*Copenhagen Consensus opening session (left to right): Anders Foch Rasmussen (Danish Prime Minister), Bjørn Lomborg (Director, Copenhagen Consensus Center), Finn E. Kydland (Nobel laureate, University of California, Santa Barbara), Thomas Schelling, (Nobel laureate, University of Maryland), Nancy Stokey (University of Chicago), François Bourguignon (Paris School of Economics and former World Bank chief economist), Jagdish Bhagwati (Columbia University), Douglass C. North (Nobel laureate, Washington University in St. Louis), Vernon L. Smith (Nobel laureate, Chapman University). The 8th panel member (not in the photo) was Robert Mundell (Nobel laureate, Columbia University in New York).*

a quantitative way in the knowledge that resources are scarce; solutions, each of which are challenged and perhaps amended by one or two other experts in the area, and then confronted with a panel who, although obviously not experts in all of these areas, have a deep understanding of economic and social issues and the ability to ask the right questions.”

Hunger leaves people more susceptible to disease, requiring more health-care spending. Those who survive the effects of malnutrition are less productive; children benefit less from education, because of physical and mental impairment. Specific interventions to help people in South Asia and sub-Saharan Africa (where 80% of the world’s undernourished children live) would have massive benefits. The Copenhagen Consensus analysis shows that devoting more money to providing micronutrients lacking in the diets of people in poor communities would be an excellent approach.

Extracted from Copenhagen Consensus 2008 press releases April 9/May 30.

Note: This is the second time that the Copenhagen Consensus (first held in May 2004) has given a high priority to policies that provide micronutrients to malnourished populations (see Nutriview 2004/3).

## Feature:

# Focus on quality in food fortification

How can you save costs in your food fortification program without compromising on efficacy? How can you be sure that the fortified food provides consumers with the desired amounts of nutrients needed for good health in a form that is safe, efficacious and affordable? A key factor is to use ingredients and formulations from a reliable source, while only quality assurance, monitoring and testing can confirm that manufacturers meet the required standards. It is unwise to blindly

choose the supplier who offers the lowest price, rather than the one providing the best value.

### The quality challenge

The food fortification process poses a complex challenge sensitive to many factors. It involves a long, usually international and often intercontinental, chain of activities and inputs, beginning with the raw materials for the basic vitamins and minerals. They have to

be synthesized, fermented, extracted and formulated specifically for the intended purpose. These basic ingredients must then be accurately weighed and blended to produce a premix that is stable, bioavailable and free from impurities of any kind. Food companies must be able to add this premix to achieve a homogeneous distribution of only minute quantities of micronutrients (parts per million) in the final product. To achieve real improvements in human nutrition and health through food fortification, health authorities need to oversee the design and control of the entire operation.

Ignoring quality at any stage of this chain increases the chances of failure. With global projections suggesting that micronutrient deficiencies are involved in more than a million deaths and US\$18 billion in economic losses every year, the potential benefits of an effective fortification program are significant. Compromising quality by only a few percent can result in a substantial loss in benefits. The greater the attention to quality, the closer the actual benefits will approach the potential benefits.

#### Quality cannot be seen

One of the strengths of food fortification is that, when done correctly, it has no perceptible effect on the characteristics of the food, and consumer behavior remains essentially unchanged. Health and nutrition improvements are the result of the daily intake of imperceptible amounts of vitamins and minerals. So consumers are not aware that they are improving their nutritional status. This is why food fortification is sometimes called the “silent solution to hidden hunger”. Its effects are hidden from the senses, as invisible and silent as micronutrient malnutrition itself. The very features that make food fortification an attractive alternative for improving nutrition also make it difficult to determine whether the program is working properly.

Fortified foods (like other food products, nutritional supplements, education programs, medical services and car repairs) can be classed as credence goods. Economists Darby and Karni introduced this term in 1973 to describe goods whose quality cannot be detected by inspecting the finished product [1]. It reflects details in the production process that have little or no influence on the objective characteristics of what you buy [2]. Normally, fortified and unfortified foods are indistinguishable; both have the same look, smell, taste and cooking properties. If you cannot easily judge the true value of something from experience or your five senses, you have no choice but to believe the claims of the producer. This is also true for many food manufacturers, who have to put their trust in the ingredient supplier. It is therefore sensible to heed the economist’s warning that: “it pays not to be too credulous” when dealing with credence goods [3].

#### Penny-wise and pound-foolish

It is another unfortunate characteristic of credence goods that, when you need to trust the supplier, it “creates

strong incentives for opportunistic seller behavior” [4]. It is easier for the seller to pass off a low quality product as a higher quality one, since “detection of false claims about credence characteristics is, by definition, rather seldom” [2]. Particularly in a very price sensitive business environment, as is the case with food processing, cutting corners to lower costs is a constant temptation. Indeed, Gresham’s economic observation in the 16th century that “bad money drives good money out of circulation” (bad money: coins with lower content of precious metal) operates in a modified form for credence goods: poor quality tends to drive out good quality.

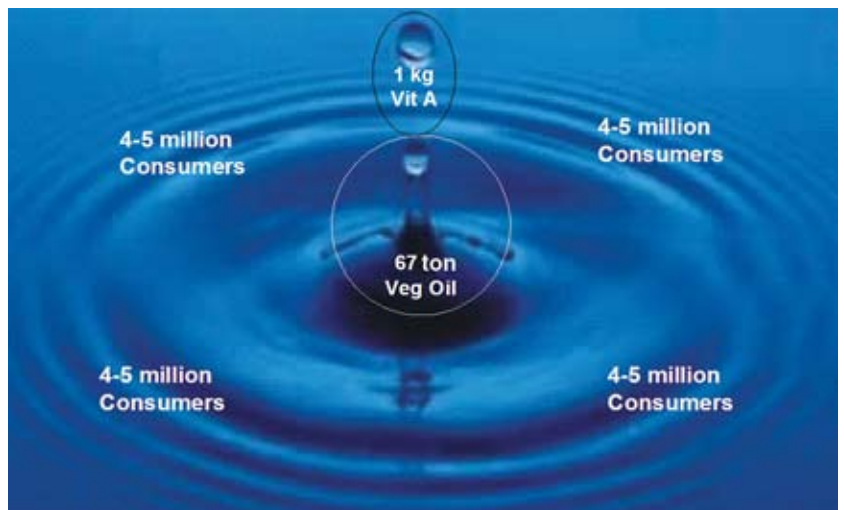
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*Only a quality-assured and system-wide approach to food fortification can benefit global health and nutrition at a reasonable cost*

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Recent scandals caused by substandard and fraudulent ingredients in foods show that these economic analyses might be correct. Over the past decades, trading of micronutrients and premixes has become increasingly global, and the market has focused on price rather than quality. In 2006, for example, vitamin C, riboflavin and vitamin A cost about half as much as they did in 1995. It is more likely that this reflects lower quality standards than lower labor costs, because food ingredient production is capital intensive.

Nevertheless, the savings from lower ingredient costs are miniscule compared to the health risks and economic losses due to inferior quality. For example, you might save a few dollars on a kilogram of vitamin A for the fortification of margarine and cooking oil. However, this can impair the quality of 67 metric tons of fortified food. As a result, some five million consumers can be denied their much-needed intake of vitamin A. In addition, the producers may ultimately lose sales and their reputation, as well as having to face lawsuits. It is a classic case of “penny-wise and pound-foolish”.



*Ingredient costs: Like a drop of water in the ocean*

### Quality assurance mechanisms needed

Implementation of fortification programs is technically simple. Nevertheless, there remain many threats to the long and delicate quality chain. Simply heeding the old Roman adage of caveat emptor (let the buyer beware) may not be sufficient to ensure an acceptable level of quality. Mechanisms outside the marketplace are needed. The many public and private partners working to bring the benefits of food fortification to developing countries might consider some modest investments in the following areas:

1. Government regulatory agencies responsible for food quality and safety are in a key position to assure quality, both in the market place and at the point of manufacture. It needs investment in training and laboratory equipment, and possibly some support for the management and operation of national regulatory agencies. This might involve significant reform and capacity building.
2. Given the international scale of the supply chain, national authorities are not in a position to assure quality over the entire process. It is therefore important to establish international codes of practice or other certification processes. The Pan American Health Organization (PAHO) has developed a draft Code of Practice for Premix Operations (see Nutriview 2007/3). While this is a promising start, no mechanisms are currently in place to assure the quality of international trade in micronutrients or premixes. A multisectoral international dialogue would be an enormous step forward.
3. Fortifying with a single micronutrient is not the most effective alternative, because individuals commonly suffer from multiple deficiencies. Evidence suggests that interventions require a holistic approach with

a range of interdependent vitamins and minerals to be successful. However, the evidence base and consensus recommendations for this comprehensive approach are still incomplete. More research is needed to find an optimal solution.

4. The concept of food fortification to reduce the prevalence of micronutrient deficiencies is compelling. Today, significant investment is understandably focused on producing adequate amounts of fortified food, and high coverage of populations. This needs to be matched with investment in evaluation of actual results.

Food fortification technology offers vast opportunities to benefit global health and nutrition at a reasonable cost. Experience suggests that you cannot successfully transfer food fortification to developing countries simply by providing isolated technical inputs. It requires a quality-assured and system-wide approach. A renewed focus on quality can go a long way to ensuring that a fortification program lives up to its enormous promise.

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The DSM Task Force  
"Quality is Essential"

## Feature:

# A new tool to evaluate iron bioavailability

To effectively alleviate iron deficiency (which currently affects about 50% of children, 42% of women and 26% of men in developing countries) foods should ideally be enriched with an iron product that provides the best nutritional performance (high bioavailability). In reality, however, poorly soluble elemental iron powders continue to be the dominant iron forms used in fortification programs in many countries. The relatively low cost of such products and the lack of undesirable interactions between them and the food vehicle make them attractive from a technological point of view. But how well do they improve iron status? Product evaluations based on human efficacy studies are time consuming and usually cost prohibitive. So a simple, rapid and low-cost alternative is desirable.

### A promising in-vitro test

SUSTAIN, in collaboration with research partners in industry, government and academia, recently undertook laboratory research and human efficacy trials that showed significant differences among different types of elemental iron powders in attributes correlated with bioavailability. They have therefore developed a simple in-vitro screening procedure that accurately and reliably predicts the potential efficacy of iron fortificants in humans [1]. This tool holds great potential for estimating how well different iron forms are likely to be absorbed from foods during digestion. Industry can use it to initially screen new products (and decide which merit further evaluation in human trials), and in quality control to periodically evaluate product

batches during manufacturing. Its use can also support innovation to improve product performance.

To develop this tool, which is based on rates of dissolution in dilute hydrochloric acid, SUSTAIN collaborated with industry and drew upon published research [2, 3]. As an initial step (and as a component of the comprehensive review of elemental iron powders) SUSTAIN evaluated existing bioavailability screening technologies, and concluded that none are better than dissolution rate from the point of view of low cost and reliability. Powder dissolution rates correlated significantly with several metallurgic properties that affect bioavailability, and with results from AOAC rat hemoglobin repletion assays for relative bioavailability. Dissolution rates of two powders (electrolytic/A131 and H-reduced/AC-325) were also in qualitative agreement with human efficacy results.

Nine laboratories initially evaluated the dissolution method for reproducibility in a collaborative study in 2003. Results were promising, indicating that it will be an accurate and efficient method for screening iron fortificants. The protocol was further refined in 2004 and early 2005 to optimize its parameters (e.g. time, temperature, speed). The tool therefore meets the multiple criteria of accuracy, speed and practicality.

### Ensuring effective standards

Use of the method could help fuel a move away from static government requirements on fortification levels that do not consider bioavailability. Premix and milling companies have expressed considerable interest in the screen, particularly if it could be integrated into regulatory standards and/or guidelines for product recommendation and quality control. Most standards regulating the use of iron fortificants in food products worldwide do not set minimum requirements for nutritional performance. As a result, industry continues to go for the lowest cost (products that are stable in the food, but may have little effect on nutritional status). Incorporation of dissolution screening requirements in product specifications could help ensure the manu-

facture and use of products that either meet a certain dissolution rate threshold; or that dissolve as well as or better than an established, calibrated standard.

Additional work is needed to confirm the robustness of the protocol (capability of generating precise results when parameters vary slightly). The finalized protocol will then be subjected to a collaborative study again to ensure that uniform results are achievable by different laboratories.

SUSTAIN has discussed the preliminary protocol with international standards officials at the Food Chemicals Codex (FCC), AACC International (formerly the American Association of Cereal Chemists) and ASTM International (formerly the American Society for Testing and Materials). ASTM has given positive feedback about the protocol's potential for validation. Following validation, SUSTAIN will convene an expert panel to evaluate current iron recommendations, review recent research (including human efficacy studies directly comparing the product's dissolution rate with its effect on iron status), and recommend protocols for practical applications of the method in the manufacture and regulation of iron fortificants.

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### Photos

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