Nutrition
Science ⇄ Policy

January 1999: 25–31

Iron and Folate Fortification in the Americas to Prevent and Control Micronutrient Malnutrition: An Analysis

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Although there has been a remarkable decline in the proportion of malnourished children in Latin America, micronutrient deficiencies, especially iron deficiency anemia, remain significant public health problems. A substantial reduction in the prevalence of iron deficiency anemia is an important goal for the end of the decade. Interest in fortifying wheat flour and dry-milled maize flour is thus growing, and significant experience in the fortification of flours with iron and the B vitamins, including folate, is emerging. It is necessary to ensure that fortification levels and standards, legislation, and quality assurance and control measures are in place nationally and harmonized regionally.

This paper was presented in abbreviated form at the interagency meeting "Iron Fortification in the Americas" held at the headquarters of the Pan American Health Organization/World Health Organization, Washington, DC, March 17, 1998.

Background: The Problem

Micronutrient malnutrition is a serious threat to the health and productivity of more than 2 billion people worldwide, although it is largely preventable.[1] Women and children, owing to their increased nutritional requirements for reproduction and growth, are more prone to iron deficiency anemia and other micronutrient deficiencies.[2,3]

This paper reviews the magnitude and consequences of iron deficiency in the Pan American Health Region of the World Health Organization, discusses fortification as a way to prevent iron (and folate) deficiency, describes the current status of fortification with iron and folate and associated critical issues, and offers some conclusions.

Iron deficiency anemia is a major cause of low birth weight and maternal mortality[4] and has recently been re-recognized as an important cause of cognitive deficit in infants and young children. Iron deficiency has a profound affect on productivity and, therefore, has economic implications for countries in which it is a significant public health problem.[5,6] Folate deficiency, another cause of anemia, has also been associated with neural tube defects and, more recently, cardiovascular disease.

Micronutrient deficiencies, especially iron, still represent significant problems in most countries of the Pan American region. An estimated 94 million people suffer from iron deficiency anemia and/or iron deficiency in the Pan American region—North, Central, and South America—less than in other World Health Organization (WHO) regions, but still a significant proportion.[7] In Central and South America, iron deficiency anemia affects approximately 30% of children and 35% of pregnant women, indicating a problem of high public health significance, although some of the later surveys suggest there may have been some improvement in recent years in some countries, at least with regard to the incidence of anemia in children.[8] The problem is severe in some Andean and Caribbean countries, where up to 60% of pregnant women are anemic.[7] There are also likely to be deficiencies in vitamin A, iodine, some B vitamins, and probably zinc at levels of public health significance in many countries of the region.[8]

Fortification to Prevent and Control Iron Deficiency Anemia

The plan of action developed for the control of iron deficiency anemia in the Americas identifies four main strategies: (1) diet diversification and improvement through

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communication, (2) supplementation, (3) fortification, and (4) epidemiologic surveillance.[9] Fortification of an appropriate food vehicle with specific nutrients has been practiced in numerous industrialized countries for many years with considerable success.[10–13] Fortification efforts have in the past been less effective, in terms both of start-up and of sustainability, in developing countries compared with the more industrialized world.[14] However, even in 1995, 17 countries in Latin America were routinely fortifying with at least one micronutrient and sometimes more.[15] During the last few years, the experience with sugar fortification and private sector involvement in fortification activities in many Latin American and Asian countries suggests that the time is now ripe for a considerable expansion of fortification as a prime approach to address micronutrient malnutrition.

Fortification is only one arm of a strategy, but by becoming commercially viable and sustainable, it can reduce the size of the at-risk population and the need for other measures such as supplementation (Figure 1). Fortification of foods, especially infant foods and cereal-based products, with iron has been successful in reducing levels of anemia in Sweden and the United States, as well as in Chile and Venezuela.[14,16,17] Fortification has also been identified as one of the most cost-effective and sustainable approaches to controlling iron deficiency anemia.[18] With improved iron status, gains in productivity and take-home pay have been shown to increase by 10% to 30%.[19]

Less information exists on the cost effectiveness of other fortificants, but an economic analysis of the fortification of grain flour with folate found that by averting costly birth defects, folic acid fortification of grain in the United States would probably yield a substantial economic benefit.[20] Whether this would necessarily be true in countries where tertiary and other care is considerably less costly or inaccessible to those at most need is unknown.

Current Experience in Wheat Flour Fortification in Latin America

Flour enrichment was first introduced in the United States during World War II to prevent pellagra and subclinical deficiencies of thiamin, riboflavin, and niacin, then common in large segments of the less privileged population living in southern states.[13] In response to public health goals of reducing deficiencies of certain B vitamins and iron, the Food and Drug Administration (FDA) in the 1940s and 1950s established standards of identity for enriched staple foods (e.g., flour, bread, rice, cornmeal) and specified levels of thiamin, riboflavin, niacin, and iron to be added.[21]

Chile in the 1950s was the first Latin American country to fortify with iron, although not explicitly for anemia control. In fact, iron was added to be consistent with North American standards, but the fortification was predominantly with thiamin to prevent Wernicke-Korsakoff syndrome in the relatively large population of heavy alcohol drinkers.[16]

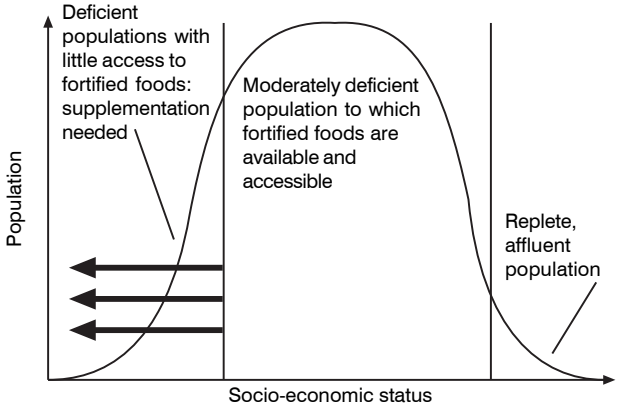

Figure 1. Paradigm for increasing micronutrient intakes in deficient populations.[12]

Legislation on restoration, i.e., low-level, fortification with iron similar to North American levels was passed in a number of Latin American countries in the 1960s but was generally not enforced. Several millers, however, began to fortify anyway. Such legislation was recently modified in Costa Rica, El Salvador, Guatemala, and Panama to reach fortification levels. Wheat flour fortification has been implemented in Jamaica since 1984, including exports to other Caribbean countries. In 1993, Venezuela legislated fortification of wheat flour with iron and B vitamins, and of corn flour with vitamin A, iron, and B vitamins.[22] At least 18 governments in the region now are implementing fortification to provide iron sources to their people through fortified wheat flour (Tables 1 and 2).

In Nicaragua, an agreement between the government and private sector millers regarding flour fortification was brokered, with national fortification launched by the minister of health in November 1997. Further emphasis on legislation and quality assurance is needed. In Honduras in May, the results of the national anemia survey showed a 26% anemia rate among women and a 34% rate in preschool children. These numbers prompted general agreement that wheat flour should be fortified with iron (previous legislation on enrichment levels had not been enacted). Following technical assistance on recommendations for legislation and quality assurance, Honduras has now begun the national fortification of wheat flour.

In 1997, wheat flour fortification began to be implemented in Colombia, Costa Rica, Ecuador, Panama, and Peru. In El Salvador, legislation on wheat flour fortification was passed in 1995 and implementation began in early l996. In Bolivia, the president and his wife inaugurated the wheat flour fortification program in July 1997. This is still an executive order without legislation, but implementation is going ahead at the mills. In Peru, legislative and

Table 1. Legislated Levels of Wheat Flour Fortification in Central America and the Caribbean, 1998

Country	Thiamin (ppm)	Riboflavin (ppm)	Niacin (ppm)	Folate (ppm)	Iron (ppm)	Legislation
Belize	6.0	2.5–3.5	35–45	0.35–0.45	55–65	Proposed 1997
Costa Rica[a]	6.0	4.0	55	1.5	60	Revised 1997
Dominican Republic	4.5	2.7	36	—	30	Implemented 1992
El Salvador[a]	4.0–6.0	2.5–3.5	35–40	0.35–0.45	55–65	Revised 1996
Guatemala	4.0–6.0	2.5–3.5	35–40	0.35–0.45	55–65	Revised 1993
Honduras[a,b]	4.4	2.6	35.6	1.5	60	Revised 1997
Jamaica	6.3	3.9	53	—	44	Implemented 1984
Nicaragua[b]	4.0–6.0	2.5–3.5	35–40	0.9–1.3	55–65	Proposed 1997
Panama[a]	6.0	4.0	55	1.5	60	Revised 1997
CARMI Regional Agreement	6.0	4.0	55	1.5	60	1997

[a]Original legislation was passed in the 1960s.
[b]Fortification has been implemented since 1997; legislation is pending approval.

regulatory systems were put in place and fortification began in February l997, but at relatively low levels and only with iron.

In Ecuador, the newly reappointed Micronutrient Committee reaffirmed an earlier commitment to fortify wheat flour, and the fortified product began to be marketed in February 1998. Results of an anemia baseline survey showed an average anemia rate of 40% in pregnant women and 70% in infants, giving further incentive for rapid fortification. This had already begun but was officially launched on March 12, 1998, in the presence of the president of Ecuador and the minister of public health. More recently, legislation on wheat flour fortification was passed in Paraguay.

There are clear advantages to a regional approach to fortification in terms of exports and imports, harmonization of standards, and common legislative approaches. Argentina fortifies the wheat flour it exports with micronutrients, but not the flour that is sold and consumed domestically.[23] Along with national governments and other regional groups such as the Central America and Panama Nutrition Institute (INCAP), the Pan American Health Organization (PAHO), and the United Nations Children's Fund (UNICEF), the Opportunities for Micronutrient Interventions Project/U.S. Agency for International Development (OMNI/USAID) has been involved in a regional approach to harmonize fortification practices throughout Central America, focusing mainly on wheat flour fortification. Early in 1997, this initiative, known as the Central American Regional Micronutrient Initiative (CARMI), made an assessment and situation analysis of fortification throughout the region, which was the basis for a work plan to strengthen fortification activities. INCAP has been designated the technical support center for this effort and is coordinating regional workshops and follow-up technical assistance in policy advocacy, legislation, quality control, and monitoring.

A regional workshop of Central American governmental policy makers met in July 1997 in Guatemala and made substantial progress in the harmonization of technical specifications. Most participants (mostly representatives of ministries of health, economy, and/or finance) agreed on a basic set of standard regulations, including proper food labeling, as well as on a basic framework for a quality assessment/quality control system at the factory level and for monitoring fortified products at the factory and household levels through periodic national household surveys in all seven countries.[24] A subsequent regional workshop in January 1998 brought key representatives of governments and food producers together to ratify the proposed Central American harmonized technical specifications for fortified foods, which set the stage for a mutually rewarding public-private sector partnership.

During the Asociacion Latinoamericana de Molineros

Table 2. Legislated Levels of Wheat Flour Fortification in South America, 1998

Country	Thiamin (ppm)	Riboflavin (ppm)	Niacin (ppm)	Folate (ppm)	Iron (ppm)	Legislation
Bolivia	3.6	2.2	31	1.4	51	Proposed 1997
Chile[a]	6.3	1.3	13	—	30	Revised 1967
Colombia	6.5	4.0	55	1.5	60	Implemented 1996
Ecuador	4.5	7.5	55	0.6	60	Implemented 1996
Peru	—	—	—	—	30	Implemented 1996
Venezuela	1.5	2.0	20	—	20	Implemented 1993

[a]Original legislation was passed in 1951.

(ALIM) meeting in Lima, Peru, in November 1997, a declaration of its members was approved in which they committed to fortifying wheat flour regardless of government requirement.

Critical Issues

Why Is Wheat Flour Fortification Successful?

There are several reasons why it has been less difficult to engage the private sector in wheat flour fortification than in the fortification of other vehicles. One is the low cost. Fortifying wheat flour with a premixed package of iron, vitamins B_1 and B_2, niacin, and folic acid adds on average less than 0.5% to the retail price of wheat flour.

A second reason is that manufacturers are already familiar with adding nutrients (for restoration), baking aids, whiteners, and other ingredients to flour during the wheat milling process. Many mills in Latin America have been adding iron and B vitamins for restoration for a number of years. Therefore, the idea is familiar, most machinery is in place, and quality control approaches already exist. Also, most of the wheat is imported and processed through only a few central mills, thus limiting the need to advocate for iron fortification among many millers. It seems likely that the trend toward consolidation of the milling industry and other effects of privatization will continue.

Third, with growing economic globalization, there is a need to be competitive within the region and with other regional producers who may already be marketing an improved, fortified product. Securing government commitment to control illegal importation of nonfortified wheat flour is proving to be an additional motivation to fortify.

Technical Considerations: Iron Fortificants

Iron source. Different types of iron offer different advantages and disadvantages.[14] Ferrous sulfate has good bioavailability but at certain high levels causes problems in the quality of some baked products, such as bread. Different iron forms, and even the same forms at different levels, affect the final product differently. Reduced iron has been recommended for wheat flour fortification on the basis of cost and functional properties. However, the bioavailability varies depending on the particle size of reduced iron. Much of the legislation follows existing standards in other countries. Other options include iron EDTA and amino acid–chelated iron, although its use is still being evaluated.

Enrichment versus fortification. Restoration or enrichment of wheat flour returns nutrients lost in the milling process to their original levels. For iron, this is generally around 35 ppm.[25] Iron fortification is the addition of extra iron, usually up to 55–65 ppm, as is practiced in most Latin American countries. While the consensus now generally favors fortification, including for B vitamins and folic acid, for a variety of reasons some governments have made the decision to enrich only or to fortify only at moderate levels (usually because their populations have higher intakes of wheat flour products).

Multiple fortification of wheat flour. This is already being done in many countries (Tables 1 and 2). A further possibility is fortifying with vitamin A as well as iron. More research is needed about the interaction of iron and vitamin A at relatively high iron fortification levels as well as the effect of ambient storage conditions prevalent in developing countries. Vitamin A fortification of wheat flour would substantially increase the cost of the fortificant premix, but it would still be less expensive than fortifying sugar with vitamin A. The addition of vitamin A is likely to contribute to reducing iron deficiency and anemia,[26,27] and might possibly increase the bioavailability of iron in some circumstances,[17] although this needs confirmation.

Interestingly, in Venezuela, iron fortification of wheat flour is at lower "restoration" levels and corn flour is fortified with vitamin A, B vitamins, and iron at "fortification" levels. Reduced levels of iron deficiency, even in the face of adverse economic circumstances, have been observed.[17] It seems likely that commercial corn flour will grow in importance because of its convenience. CARMI is also working to further develop and adapt multiple fortification technology for nixtamilized corn flour that is widely consumed in most Central American countries.

Naturally zinc-rich diets tend to be expensive diets, so zinc fortification is an important consideration, especially since it appears that daily intakes are more useful physiologically than intermittent dosing (as in supplementation).[28] Food is easily fortified with zinc; the forms used are bioavailable and stable, and a wide variety of foods in countries such as the United States are presently fortified with zinc. The U.S. Food and Nutrition Board of the National Academy of Sciences suggested zinc restoration at a level of 22 ppm for wheat flour (along with other micronutrients) in 1974, but its suggestion has not been enacted.[28] There seems no reason not to recommend it, but there is relatively little documentation on its use in cereal flours.

Wheat Flour Consumption Levels

There are two main issues regarding consumption levels of wheat flour. One is the larger question of whether wheat flour products are consumed, and to what extent, by a target population (Tables 3 and 4). In countries with higher wheat consumption, such as South America (average intake > 100 g/person per day), this is not an issue. In Central America, where corn flour is the predominant staple consumed by lower-income groups and average intake of wheat flour products is well under 100 g/person per day, it is a real consideration whether wheat flour fortification reaches the intended beneficiary population. Because of the ease of fortification, the low cost, and the growing

consumption levels of prepared wheat products, all of the Central American governments have decided to fortify and try to reach as much of the population as they can with the highest possible iron levels.

A related question is whether and how much the consumption of wheat flour–based goods will continue to increase. Related to this is that, of the 35 Latin American nations, only 11 produce wheat and only one, Argentina, is self-sufficient in wheat. Corn remains the dominant grain in Mexico, Central America, Colombia, and Venezuela, although wheat flour consumption has steadily increased in the latter two countries.

The second issue is the amount of fortified flour consumed by target individuals at the household level. Do women and children, the groups at highest risk of iron deficiency anemia, eat enough processed wheat products at regular intervals to justify a fortification intervention? Members of the poorer socioeconomic strata (those most at risk of anemia) generally consume fewer wheat flour products. In general, low socioeconomic status remains a predictor of community rates for iron deficiency, even in countries where iron fortification is widespread and has been successful in reducing iron deficiency (e.g., Hispanic populations in Massachusetts).[29,30] Anemia in children younger than 2 years remains a significant problem in Chile, despite fortification, and in Argentina, which is one of the world's largest consumers of meat.

Although gross per capita consumption of flour and flour products can be calculated, there often are few data on intrahousehold consumption. Whenever possible, consumption questions are being added to household surveys, e.g., in Bolivia, Ecuador, Honduras, and Nicaragua, but quantitative information is cumbersome and costly to collect. It will also be important to track consumption over time to see whether levels should be adjusted and whether the product is reaching further into the target market.

Table 3. Consumption of Wheat and Wheat Products in Central America and the Caribbean

Country	Per Capita Wheat * Consumption (kg/year)	Per Capita Wheat Flour Consumption (g/day)[a]
Belize	55.55	106.5
Costa Rica	43.91	84.21
Cuba	57.02	109.3
Dominican Republic	33.9	65.01
El Salvador	47.02	90.17
Guatemala	25.78	49.44
Honduras	26.52	50.86
Jamaica	67.61	129.66
Nicaragua	22.72	43.57
Panama	43.57	83.55

Source: FAO Food Balance Sheets, 1984–86.
*Wheat and wheat products include wheat, wheat flour, wheat bran, macaroni, wheat germ, bread, bulgur, pastry, wheat starch, wheat gluten, breakfast cereals, wafers, mixes and doughs, and food preparations of flour meal or malt extract.
[a]Kilograms/year × 0.70 (average wheat flour extraction) × 1000/365 = 1.91.

Table 4. Consumption of Wheat and Wheat Products in Other Latin American Countries

Country	Per Capita Wheat * Consumption (kg/year)	Per Capita Wheat Flour Consumption (g/day)[a]
Argentina	115.35	221.21
Bolivia	56.80	108.93
Brazil	42.63	81.75
Chile	118.78	227.79
Colombia	29.79	57.13
Ecuador	27.69	53.10
Mexico	39.99	76.69
Paraguay	20.53	39.37
Peru	47.17	90.46
Uruguay	83.83	160.76
Venezuela	45.86	87.95

Source: FAO Food Balance Sheets, 1984–86.
*Wheat and wheat products include wheat, wheat flour, wheat bran, macaroni, wheat germ, bread, bulgur, pastry, wheat starch, wheat gluten, breakfast cereals, wafers, mixes and doughs, and food preparations of flour meal or malt extract.
[a]Kilograms/year × 0.70 (average wheat flour extraction) × 1000/365 = 1.91.

Legislation and Regulation

As described above, legislation, usually for nutrient restoration, has been in place for many years but not enforced. In 15 countries, nutritional enrichment of cereal flours is now included in the legal code (Tables 1 and 2). Most Latin American and Caribbean countries are now committed to revising their food laws to be in line with Codex Alimentarius and its focus on quality control. To ensure that regulations are met, quality assurance and quality control are gaining increasing attention.

Quality control and quality assurance. Training is essential in a proper quality assurance system to ensure that the micronutrients in the fortified products are reaching consumers at prescribed levels. After negotiations with the Wheat Millers' Association of the Latin American countries (ALIM), a 3-week training program supported by USAID, the International Life Sciences Institute, and the Micronutrient Initiative (MI), was held at the American Institute of Baking (AIB) at Kansas State University, with participation from the University of Arkansas and OMNI, as the first step to strengthen ALIM's capacity to provide training to its country members on fortification technology and quality assurance and quality control. This capability will be established at the regional training center at the Latin American Wheat Millers Association (ESLAMO) near Caracas, Venezuela. Beginning in early 1998, courses on quality assurance and monitoring, conducted by instructors trained at AIB, will become part of the standard

curriculum for Latin American wheat millers.

OMNI and MI, with input from INCAP and PAHO, have completed a first draft of a wheat flour fortification manual. This will provide a step-by-step methodology for advocacy, decision making, fortification technology, mill implementation, legislation, quality assurance and quality control, and monitoring systems, including practical information such as a listing of equipment suppliers and where fortificant premixes can be purchased. PAHO also recently published general guidelines on the basics of quality assurance in micronutrient fortification.[31]

Conclusions and Recommendations

Wheat flour fortification has become policy in most countries in Central and South America, and implementation has begun or will begin early this year. To ensure the sustainability of high-quality fortified products, emphasis now needs to be directed toward adequate quality assurance and monitoring systems.

Critical issues that remain to be addressed include (1) appropriate iron compounds (their stability and cost), (2) trade and regulatory issues, particularly at a regional level, (3) the need to reach those at highest risk of iron deficiency, (4) other vehicles such as semolina-based pasta and noodles (in much of Latin America, pasta is made from wheat flour rather than semolina), (5) strengthening quality assurance/quality control, and (6) extension of multiple fortification, including assessing cost (e.g., of adding folate), the technical feasibility of adding vitamin A, and the need for adding zinc and perhaps other micronutrients.

The substantial reduction of iron deficiency anemia has been endorsed as an achievable goal by virtually all Latin American and Caribbean countries. Public health measures, including supplementation of pregnant women and young children, will continue to be necessary, as will socioeconomic and other specific measures, such as education, directed at those persons at most risk. Governments should continue to demonstrate their key role in establishing a mutually rewarding partnership with the private sector by ensuring that relevant legislation is supportive of the public health measures and private sector initiatives needed to address micronutrient malnutrition.

The Latin American countries, in particular, seem ideally positioned, with their existing infrastructures, the recognized need, and the rising socioeconomic environment to tackle micronutrient malnutrition. The fortification of flours with iron and B vitamins, and perhaps other micronutrients, will play an increasingly larger role in achieving this goal.

Acknowledgments. The authors wish to acknowledge the support of Dr. Frances Davidson and Dr. Tim Quick of the Population, Health, and Nutrition Center, U.S. Agency for International Development (USAID). This publication was made possible through support from the Office of Health and Nutrition, Bureau for Global Programs, Field Support and Research, USAID, under the terms of contract HRN-5122-C-00-3025-00. The opinions expressed herein are those of the authors and do not necessarily reflect the views of USAID.

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