

## Iron Fortification of Flours in Venezuela

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This paper reviews a conference about the impact of the iron fortification program in Venezuela; it was presented at the Pan American Health Organization regional technical meeting: "Iron Fortification: Where Are We in Terms of Iron Compounds," held in Washington January 10-12, 2001. Some of the data presented were published in the *American Journal of Clinical Nutrition*,<sup>1</sup> including stimulating results about the impact of fortification of precooked corn and white wheat flours, as well as the prevalence of anemia and iron deficiency in the Venezuelan population.

This article reports results from three surveys carried out in 1997, 1998, and 1999 on the same age and socioeconomic group that had been evaluated in 1990, 1992, and 1994.<sup>1</sup> This article also shows the impact of iron fortification programs and the influence of other factors on the prevalence of iron deficiency and anemia during the last 7 years.

### Background

During the period 1960 to 1985 the Venezuelan population experienced a progressive reduction in the prevalence of iron deficiency owing to the improvement in food consumption in the low socioeconomic class, and the reduction in the prevalence of hookworm infection in the rural population.<sup>2-5</sup> During the period 1978 to 1985 prevalence of anemia and iron deficiency in the lower socioeconomic strata was 9% and 29%, respectively in 1- to 3-year-old children; the prevalence of anemia and iron deficiency was 5% and 23%, respectively in women of childbearing age.<sup>6,7</sup> A survey carried out in the city of Maracaibo in 1983 in the low-socioeconomic-status population showed a prevalence of 8% anemia and 26% iron deficiency in women 15 to 45 years old.<sup>5</sup>

The economic crises that started in 1983 with the devaluation of Venezuelan currency produced a progressive reduction in the quality and quantity of food consumption, characterized by a lower intake of meat, veg-

etables, and fruit, as well as cereals, grains, and tubers. The dietary iron intake diminished from 14 to 11 mg/day.<sup>8</sup>

In 1990 the mean prevalence of iron deficiency and anemia in children and adolescents in the labor and lower socioeconomic strata of Caracas was 14% and 4%, respectively, and 2 years later this number increased to 37% and 19%, respectively. As a result, in 1993 the Venezuelan government nominated a special commission for the enrichment of food (CENA), which began a program to fortify both precooked corn and wheat flours with iron and vitamins.

The Venezuelan diet is based on consumption of cereals, especially precooked corn and white wheat flours. The intake of these two cereals represents 45% of the total daily calories consumed by the low-socioeconomic-status population.<sup>8</sup> In 1992 per capita consumption of precooked corn flour was 80 g/day for the total population and 110 g/day for people of low socioeconomic strata. Socioeconomic conditions continued to deteriorate and in 1999 precooked corn flour consumption dropped to 84 g/day. Moreover, corn flour sales diminished during 1998 and 1999 compared with 1997. However, wheat flour consumption increased from 85 g/day in 1992 to 104 g/day in 1999. This change in flour consumption implies a reduction in vitamin A intake because wheat flour is not fortified with vitamin A; this could result in lower absorption of iron compared with fortified corn flour.

The corn flour industry produces 60 million tons per year; 10 million tons of processed corn are transformed into 700,000 tons of corn flour. Wheat is mainly imported from the United States and Canada and 12 million tons of processed wheat produce 700,000 tons of wheat flour.

### Fortification Program

#### Iron Compound

The compulsory fortification of precooked maize flour started to reach the total population in February 1993. It contained 50 mg of iron as ferrous fumarate per kilogram plus vitamin A, thiamin, riboflavin, and niacin (Table 1). The fortification of wheat flour was started in August of

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**Table 1.** Enrichment of Food Vehicles in Venezuela

	Precooked Maize (flour/kg)	White Wheat (flour/kg)
Vitamin A (IU)	9500	—
Thiamin (mg)	3.1	1.5
Riboflavin (mg)	2.5	2.0
Niacin (mg)	51.0	20.0
Iron* (mg)	50.0	20.0

\* As ferrous fumarate until 1994. Since then, 30 mg/kg as ferrous fumarate and 20 mg/kg as electrolytic iron.

the same year. In this program the flour was enriched with 20 mg of iron as ferrous fumarate per kilogram, plus thiamin, riboflavin, and niacin (Table 1).

During the first year of iron fortification the only adverse effect observed occurred in two regions of the country. Hard water was used for making cornbread the night before it was consumed. The people noticed that the bread turned slightly dark the day after it was baked; this organoleptic change was confirmed in the laboratory. Fortunately, hard water and cooking procedures were factors only affecting 1% of the population of these regions. This inconvenience determined a change in the iron fortification pattern and from February 1994 on the precooked corn flour was enriched with 30 mg/kg of iron as ferrous fumarate and 20 mg/kg of electrolytic iron.

### Surveys

After the conclusion of the Venezuelan Project on Nutrition, which covered 1978 to 1985, FUNDACREDESA (Foundation for the study of National Growth and Human Development) started a new nutrition project called "Living conditions of the Venezuelan population." This project included yearly national surveys on children 7, 11, and 15 years old to continue the longitudinal study on growth and development. This project conducted surveys during 1990, 1992, and 1994. Since 1997 a new project "Impact of flours fortification program in Venezuelan population" has conducted surveys in 1997, 1998, and 1999.

Blood samples taken from the children were used for the measurement of several biochemical variables including hematologic profile: blood hemoglobin concentration<sup>9</sup> and serum ferritin concentration.<sup>10</sup> The cut-off used for the identification of subjects with anemia was hemoglobin concentration below 11.5 g/dL for male and female children 7 years old, 12 g/dL for females 11 and 15 years old, and 12.5 g/dL and 13 g/dL for males 11 and 15 years old, respectively. Children were classified as iron deficient when serum ferritin concentration was lower than 10  $\mu\text{g/L}$  for children 7 and 11 years old and lower than 12  $\mu\text{g/L}$  for children 15 years old.<sup>7</sup>

**Table 2.** Impact of Venezuelan Flour Fortification Program on the Prevalence of Anemia and Iron Deficiency in Children and Adolescents in the Low Socioeconomic Strata of the Caracas Population (surveys 1992–1999)

Year	Anemia (%)	Iron Deficiency (%)
1992	19	37
1994	9	16
1997	16	13
1998	19	11
1999	17	16

### Quality and Quantity Control

From 1993 (when the fortification program started) to 1999, random samples of commercial flour packages have been taken from shelves at food stores by trained persons from The National Institute of Hygiene and The National Institute of Nutrition; this occurred approximately every 2 months for 7 years and the samples were analyzed in the laboratory for iron content. The analysis of iron content showed that it ranged from 80 to 120% of the expected value.

### Impact of Fortification Program on Prevalence of Iron Deficiency and Anemia

Table 2 shows the results of the surveys carried out between 1992 and 1999 on the prevalence of iron deficiency measured by serum ferritin concentration and the prevalence of anemia measured by hemoglobin concentration.

The comparison between the 1992 and 1994 surveys of the Caracas population showed a significant reduction in the prevalence of iron deficiency and anemia, which dropped from 37% and 19% in 1992 to 16% and 9% in 1994, respectively, after only 1 year of fortification. Table 2 also shows changes in the prevalence of anemia and iron deficiency in children and adolescents from low socioeconomic strata of the Caracas population in the surveys carried out in 1997, 1998, and 1999. There were no significant differences for anemia or iron deficiency in the last three surveys.

Prevalence results from the last 7 years seem to indicate that after a dramatic reduction in 1994, iron deficiency tended to stabilize. Prevalence of anemia also diminished dramatically from 1992 to 1994, but for the last three surveys it reached the same levels of prevalence as were reported before the fortification program was started.

The median ferritin concentration has a clear tendency to increase, even though the increase was small in the last three surveys. This index increased significantly in 1997, 1998, and 1999 compared with the 1992 survey, when the iron fortification program had not yet been started. The median ferritin concentration changed from

**Table 3.** Statistical Analysis of Ferritin Concentration in Total Samples (7, 11, 15 years) from the 1992, 1994, 1997, 1998, and 1999 Surveys

Survey	Mean ( $\mu\text{g/L}$ )	SE	Median	95% Confidence Interval	n
1992	13.46 <sup>D</sup>	1.05	15	12.22–14.83	282
1994	20.54 <sup>C</sup>	1.04	22	18.96–22.25	317
1997	21.91 <sup>A,B,C</sup>	1.03	24	20.51–23.38	571
1998	26.08 <sup>A</sup>	1.26	28	24.26–28.02	466
1999	24.1 <sup>A,B</sup>	1.03	27	21.03–24.3	537

<sup>A–D</sup> Means with no common letters differ,  $P < 0.001$ .

SE = standard error.

13  $\mu\text{g/L}$  before the fortification program started to 21  $\mu\text{g/L}$  in 1994. In the 1997, 1998, and 1999 surveys serum ferritin concentration was 24, 28, and 27  $\mu\text{g/L}$ , respectively (Table 3).

### Final Comments

For successful iron fortification, it is important to select food vehicles that are consumed daily, to choose an iron compound that is well absorbed, and to maintain control of the enrichment.<sup>11–14</sup> In the case of the Venezuelan fortification program all three premises have been fulfilled. The precooked maize bread is consumed by the entire population (except infants); this target population consumes wheat flour from bread or pasta. The iron bioavailability of ferrous fumarate has been demonstrated; it is absorbed similarly to ferrous sulfate when enriched in the flours mentioned.<sup>15,16</sup> The industrialized process of fortifying each flour allows full control of the ingredients.

The impact of iron fortification on the prevalence of iron deficiency and anemia deserves several comments. There was a striking reduction in the prevalence of iron deficiency and anemia after 2 years of fortification. For the next three surveys (1997–1999), however, prevalence of anemia began to increase, returning to pre-fortification levels (19%). In 1994 prevalence of iron deficiency diminished significantly and continued dropping slowly during 1997 and 1998. In 1999, however, prevalence values were the same as those reported in 1994. The overall tendency for prevalence of iron deficiency was to stabilize after a significant reduction in 1994. This apparent lack of effect of the fortification program on anemia prevalence has several potential reasons:

Living conditions in Venezuela continued to deteriorate since 1985 when the socioeconomic crisis started. FUNDACREDESA calculated the cost of a monthly base diet per month for a family of five (father, mother, and three children); this diet contains only locally produced foods and the main food constituents are corn flour, rice, plantain, potatoes, milk, fruit, meats, vegetables, and eggs. The average macronutrient contents are

as follows: 9257 kJ energy, 65 g protein, 343 g carbohydrate, and 66 g fat. In 1994, monthly cost of this diet was 989 Bolívares (Bs.), which is equivalent to US\$7. In 1998 the cost of the diet increased to 142,000 Bs., which is equivalent to US\$209. During this period 10% of the middle class, 20% of the labor class, and 30% of the low socioeconomic class were unable to cover their nutritional requirements with this base diet.<sup>17,18</sup>

Wheat flour consumption increased from 85 g/day in 1994 to 104 g/day in 1999, whereas precooked corn flour consumption dropped from 94 g/day in 1994 to 84 g/day in 1999. The difference in flour consumption implies a reduction in vitamin A intake because wheat flour is not fortified with vitamin A; this could result in lower absorption of iron compared with fortified corn flour.

C-reactive protein was measured in the 1998 and 1999 surveys. Samples included all cases with anemia (with or without iron deficiency). In the 1998 survey 89 cases were analyzed; three were positive for anemia. In 1999, 93 samples were analyzed and six were positive. Anemia owing to bacterial infections was ruled out but viral infections, especially dengue, have been epidemic in Venezuela. In 1996 10,000 cases were reported; this number increased to 30,000 in 1997 and 35,000 during 1998.

Human iron absorption studies using 100 g precooked corn flour fortified with 5 mg Fe as ferrous fumarate resulted in 6.4% absorption, whereas the same amount of flour fortified with 3 mg Fe as ferrous fumarate plus 2 mg Fe as electrolytic iron had 5.6% absorption.

In conclusion, it is possible that viral infections, reduction in corn flour consumption, increased consumption in wheat flour intake (with no vitamin A fortification), continuous deterioration in quality of life, and the partial substitution of a highly bioavailable iron compound (ferrous fumarate) for a less available form of iron (elemental iron), could be responsible for the return of the prevalence of anemia to pre-fortification program levels. Finally, in spite of the fact that conditions in the country continue to deteriorate, this fortification program

has improved iron stores and maintained prevalence of anemia.

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