

# Iron Food Fortification for the Control of Childhood Anemia in Brazil

Joel Alves Lamounier<sup>1</sup>, Flávio Diniz Capanema<sup>2</sup> and Daniela Silva Rocha<sup>3</sup>

<sup>1</sup>*Universidade Federal de São João Del Rei,  
Campus Centro Oeste (UFSJ), Divinópolis, Minas Gerais,*

<sup>2</sup>*Children and Adolescents Health Nucleun,  
Faculdade da Saúde e Ecologia Humana (FASEH), Vespasiano, Minas Gerais,*

<sup>3</sup>*Universidade Federal da Bahia, Vitoria da Conquista, BA,  
Brazil*

## 1. Introduction

Iron deficiency anemia represents a serious nutritional problem worldwide, and it especially affects children and pregnant women in developing countries. According to Global Health Burden Disease Report of World Health Organization, anemia is considered the most prevalent public health problem in the World (World Health Organization [WHO], 2008), which requires public policies to combat iron deficiency and anemia. In Brazil, the National Survey of Demography and Health of Children and Women - PNDS - showed 20.9% prevalence of anemia among children 6 to 59 months, with the highest prevalence in the northeast (Brazilian Institute of Geography and Statistics [IBGE], 2010). Studies conducted between 1996 and 2007, involving children less than 5 years in different regions of the country, showed very high rates of anemia. The prevalences were 47.8-63.7% in south, 10.4-77.8% in southern, 55.1-84% in north, 35.7-89.1% in northeast, and 31-63.1% in midwest of Brazil (Jordão et al., 2009).

A meta-analysis study which included articles published in the last 10 years, the prevalence of anemia was higher than 40.0% in children under seven years old (Andrade, 2004). Also in day care centers iron deficiency anemia is considered the most common nutritional deficiency in childhood, with high prevalence (Capanema et al., 2008; Castro et al., 2011; Matta et al., 2005; Morais et al., 2005; Neves et al., 2005)

The magnitude of nutritional anemia in Brazil represents a serious public health problem, specially the short and long term affects anemia can have on growth in at-risk groups. Thus, as a result of this problem, various intervention approaches are being adopted in attempts to control and prevent anemia. One possible intervention measure, which has shown to be successful in reducing anemia in at-risk groups, is the iron fortification of foods made available to children.

Food fortification is highlighted as one of the most cost-effective health solutions to fight malnutrition among children and anemia deficiencies among women. Fortification of staple foods improves micronutrient status by delivering small amounts of micronutrients on a

daily basis. In addition, some other options, such as drinking water for consumption also has been a good alternative. Staple food fortification is routinely practiced around the globe in developed countries and contributed for decreasing childhood anemia. In developing countries, anemia is still a public health problem in a large number of these. Therefore, food fortification with iron have been considered, since it requires no change in eating habits and delivers benefit through the consumption of fortified staple foods or drinking water.

In this chapter this issue was discussed as a Brazilian experience to control and reduce anemia in childhood using the iron fortification strategy. The use of food vehicles, iron salts and their costs, as well as recent works on iron fortification of foods in Brazil are reviewed.

## 2. General aspects of iron fortification of infant foods

The fortification of foods consists in the addition of complementary nutrients to foods *in natura*. A concern with nutritional deficiencies in populations and a utilization of fortification as an intervention measure were extensively documented throughout the twentieth century. In 1910, for example, in Denmark, due to concern over vitamin A deficiency, which affected large numbers of children, health officials initiated large scale industrial fortification of margarine with vitamin A, resulting in the elimination of xerophthalmia in the population (Nilson & Piza, 1998).

Once foods are enriched with micronutrients, such as iron, large, at-risk populations will be reached over long periods without the need of effective individual cooperation (Tuma et al., 2003; WHO, 1989). Therefore, food fortification is considered highly effective and flexible, is socially acceptable and furthermore, it does not interfere with the population's dietary habits. In addition, the risk of side effects and toxicity are minimal due to reduced doses of micronutrients added to foods (Tuma et al., 2003)

Food fortification is a public health measure, and in order to be successful, several considerations should be kept in mind. First, the food vehicle of choice must be consumed regularly and in large scale by the targeted population. In addition, the selected food vehicle should be evaluated for potent absorption inhibitors, and if the added iron compound will have an impact on the iron status of the consumer. Secondly, it is important that the selected iron compound does not cause unacceptable changes in color and flavor when added to foods. Additionally, the food vehicle should be sufficiently stable during long periods of storage and during cooking in order to guarantee that true food consumption may be quantitatively capable of contributing significantly to the nutritional requirements of the population. Finally, the food vehicle must be centrally produced and proper technology is available for industrial-scale fortification (Andrade, 2004; Cardoso & Penteadó, 1994).

The objective of iron food fortification programs is to increase the dietary mineral in foods to prevent and control iron-deficiency in at-risk groups (Andrade, 2004). The fortification of foods with iron is a preferred strategy advocated by the World Health Organization. Iron added to foods has been shown to be the most efficient options to control iron-deficiency, and studies have shown improvements over a period of one to three months in people suffering from this deficiency (Nilson & Piza, 1998).

In Europe, some countries have adopted a policy of distribution of infant formula and fortified cereals, which resulted in decreasing the prevalence of iron deficiency in last decades (Hercberg, 2001). In the United States, in a cross-sectional study using data from the Centers

for Disease Control and Prevention's (CDC), five American States found that the prevalence of anemia among children dropped by more than 50% in the last two decades and was attributed to better nutritional conditions related to large-scale consumption of fortified foods and possibly better iron bioavailability in some products (Sherry et al., 2001). The prevalence of anemia (NHANES III - conducted between 1988 to 1994) in the U.S. was 3% and 9% in children aged one to two years and less than 1% and 3% for children aged three to five years with anemia iron deficiency and iron deficiency, respectively (Looker, 1997).

In Chile the prevalence of iron deficiency anemia is low in infants, preschoolers, school children, adolescents, adult men and women of childbearing age. Only pregnant women are still highly prevalent. It is likely that this low prevalence is due to fortification of flour with iron and B vitamins. The National Program for Complementary Alimentación (PNAC) distributes milk to children since 1952, while since 1970, this is enriched with iron. Through studies, the composition of output has been modified and now provides the program for infants and pregnant women milk powder fortified with iron, zinc, copper and ascorbic acid (Nilson & Piza, 1998). In Panama, children receive free via Alimentación Complementary Program (CAP) cereal fortified with vitamins and minerals. School-age children receiving iron-fortified milk and biscuits since 2006 that are offered to students in the country have also been fortified with iron and other vitamins and minerals, with coverage in difficult areas (Fontes, 2007). Cuba also adopted as a strategy to combat anemia food fortification, and the flours are enriched with iron and other vitamins and minerals since 1999. Children under two years are a priority for action, and more than 95% of the nation's children receive at subsidized prices, a pope fruit enriched with iron and vitamin C (since 2001). Milk fortified with iron is distributed, also at subsidized prices, to children under one year since 2005, and the program has covered 98% (Herrera, 2007).

For children under one year, the most appropriate strategy seems to be the fortification of child foods at home. Fortification of complementary foods (weaning foods targeted to children age) is an alternative to targeted supplementation. Commercially-prepared complementary foods typically reach higher income, more urbanized households and this tends to have been left more to the market as an initiative. Zlotkin and colleagues at the Hospital for Sick Children, University of Toronto (Canada) developed a less costly alternative of the provision of micronutrients which can be added to infant foods. It was named "home fortification" and used sprinkles, the multiple-micronutrient sachet. The biological efficacy, bioavailability, safety and acceptability of Sprinkles were tested in various scenarios, including countries such as Bangladesh, Benin, Bolivia, China, Canada, Ghana, Guyana, Haiti, India, Indonesia, Kyrgyzstan, Mexico, Mongolia, Pakistan, Vietnam (Sprinkles Global Health Initiative, 2009). Bolivia was the first country that has documented the use of home fortification with intervention at the level of public health. In 2005, the country's data pointed to 70% prevalence of anemia among children 6 to 24 months. The country adopted the strategy of distributing sachets containing iron, vitamin A, vitamin C, folic acid and zinc for all children. Each child receives one sachet per day in one meal. Some recent studies look at the costs and potential impacts of sprinkles and conclude that the benefit: cost ratio of sprinkles interventions, containing iron as well as other micronutrients, can be as high as 37:1 if one assumes that a course of intervention for four months between the ages of 6 months and one year largely protects an infant against anemia throughout childhood (Sharieff et al., 2006).

In Latin and South America, food fortification is widely practiced and can be classified in three program types: mandatory fortification of foods commonly consumed in large part by the population, such as wheat flour and corn meal; fortification targeting specific groups as in the example of foods consumed by infant and children populations, in this case cereal, powdered milk, biscuits and other industrialized products; and voluntary fortification, in which the food industry adds iron and other micronutrients to industrialized foods. The direct costs of food fortification are extraordinarily low when compared to the high social costs of micronutrient deficiencies. In most cases, according to the World Bank, the cost of fortification is less than one dollar per year to protect an individual against vitamin A, iron and iodine deficiencies. The cost to prevent an iron-deficiency alone has been estimated to be less than US\$ 0.10 per year (Nilson & Piza, 1998).

### **3. Wheat and corn flour iron fortification**

In Brazil, since 2001 the Ministry of Health made mandatory the addition of iron [30% Recommended Nutritional Intake (RNI) or 4.2 mg/100 g] and folic acid (70% RNI or 150 µg) to milled wheat and corn flour. Federal law now dictates mandatory fortification of iron instead of voluntary fortification by the grain industry. This measure has as its core objective of increasing the accessibility of milled cereal grains with iron and folic acid consumed by the Brazilian population to reduce the prevalence of iron-deficiency and neural tube defects in Brazil (National Agency of Sanitary Surveillance, 2006).

However, iron-fortified wheat flour is not always available, or it is consumed in small quantities to be affective by poor children 6 to 60 months of age (Beinner & Lamounier, 2003). Fortification of specific foods, as part of a complementary diet, has shown to be more effective for the control and prevention of iron-deficiency among infants (Andrade, 2004). In addition, and according to Hurrell (1997) it is likely that the low levels of elemental iron added to wheat flour (40 mg/Kg) would have little impact on iron nutrition, but the much higher levels added to commercial infant cereals (200-550 mg/Kg) together with vitamin C, could contribute substantially to the prevention of iron deficiency anemia.

However, this measure becomes questionable in relation to infants, age of greatest risk for anemia due to the fact that these foods are not recommended and regularly consumed in sufficient quantities to meet the iron needs of this particular group. Moreover, it is likely that the low level of elemental iron (40mg/kg) added to wheat flour has little impact on nutritional status of children. No effect of flour fortification was observed in hemoglobin levels of children under five years in the city of Pelotas. Fact can partly be explained both by insufficient consumption of flour and also by the low bioavailability of dietary iron. The study was conducted between May and June 2004, prior to the mandatory fortification of flour and 12 and 24 months after the implementation of the action which occurred between 2005 and 2006 (Assunção et al., 2007). Moreover, in Brazil, there is not a monitoring program of mandatory fortification of flour.

### **4. Fortification of milk**

The Brazilian Pediatrics Society has recommended the use of infant formula supplemented with iron for infants until the age of two as supplementary feeding with breastfeeding. However, cow's milk is an important food consumed by children especially those families of low socioeconomic status. Cow's milk presents low bioavailability of iron, and consumption of excessive amounts of fresh or pasteurized cow's milk may be associated with occult

intestinal blood loss during infancy, which may also contribute towards increasing the occurrence of anemia in infancy (Torres et al., 2000). The use of cow's milk, due to social-economic and cultural practices, is used frequently in Latin America, including Brazil, during infancy, and iron fortification of this vehicle is an inexpensive alternative to increasing iron levels in children (Torres et al., 1995).

Torres et al. (1995) studied the impact using powdered whole milk fortified with 9 mg of iron and 65 mg of vitamin C per 100 g during six months in 107 children in municipal daycare facilities, and another 228 children at public health clinics in the city of São Paulo. At baseline intervention, 66.4% and 72.8% of the children attending public daycare and public health clinics were diagnosed with anemia, respectively. At six months post study, the percentage of children still anemic decreased to 20.6% in daycare and 18% in children seen at health clinics. In a later study, Torres et al. (2000) evaluated the use of 3 mg of amino acid chelate in pasteurized cow's milk (3 mg/L). During the 12-month study, 239 children 6 to 42 months of age received, daily, one liter of fortified cow's milk. The mean hemoglobin levels at baseline for children less than 12 months, 12 to 23 months, 24 to 35 months, and 36 months of age, and older were  $10.2 \pm 1.3$ ,  $10.1 \pm 1.6$ ,  $11 \pm 1.3$  and  $11.8 \pm 1.3$  g/dl, respectively. At baseline, anemia prevalence was evaluated at 62.3%, and at six months, the percentage of children still anemic decreased to 41.8% and 26.4% after 1-year, respectively. Mean hemoglobin levels at 12 months were  $11.1 \pm 1.3$ ,  $11.6 \pm 1.1$ ,  $12 \pm 1.2$ , and  $12.1 \pm 1.0$  g/dl, for 11, 12 to 23, 24 to 35, and 36 months of age, respectively. The increases were significant for the first three age groups, but not for the last group (36 months and older).

Braga (1996) evaluated 102 children aged two to six years of age from a low, socio-economic community, enrolled in municipally funded daycare facilities in the city of São Paulo. Using an infant formula, 14 mg of iron and 100 mg of ascorbic acid were added to 200 ml of formula daily during 180 days. At the conclusion of the study, significant increases were observed in anthropometric indices (not shown here), mean hemoglobin (Hb) levels and hematocrit (Htc) values at baseline (Hb:  $12.1 \pm 0.66$  g/dl; Htc:  $35.7 \pm 1.9$ ) and post study (Hb:  $12.7 \pm 0.66$  g/dl; Htc:  $37.9 \pm 1.9$ ) showed improvements. The authors concluded that the pre-school children could benefit in the control and prevention of anemia with a permanent iron-fortification program of foods in daycare facilities.

In another study to evaluate iron fortification of infant formula, Ferreira (2000) randomly assigned 111 children, between the ages of four and six months, to two intervention groups during six months: the experimental group (68 infants) received iron fortified (1.8 mg ferrous sulfate/200 ml) milk formula and a control group (43 infants) received milk formula (0.7 mg iron/200 ml). At baseline, anemia prevalence in groups 1 and 2 was 63.2% and 67.4%, respectively. Mean hemoglobin levels in group 1 increased from 10.6 g/dl to 11.3 g/dl, however, in group 2, mean Hb actually decreased from 10.6 g/dl to 10.1 g/dl at six months. Similar significant results were seen for mean ferritin values: at baseline, ferritin values increased from 34.8 to 44.8 mcg/dl, but in group 2, mean ferritin values decreased from 41.8 to 26.1 mcg/dl. Hb and ferritin status were significantly improved in iron fortified group. Overall, the anemia prevalence decreased from 63.2% to 33.8% in group 1, and increased from 67.4% to 72.1% in group 2.

It should be noted that effectiveness of iron fortified fresh or pasteurized cow's milk and milk formulas will depend on several factors such as iron compounds, quantity, bioavailability, iron enhancers and inhibitors likely to affect bioavailability, and overall added cost to the targeted consumer.

## 5. Iron fortification of biscuits and bread rolls

Some studies were conducted on the effect of bovine hemoglobin-fortified cookies on the hemoglobin levels of 16 iron-deficient preschool children in northeast Brazil (Nogueira et al., 1992). Each child was offered five cookies per day containing 1.25 mg of iron over three months as part of their normal school meal program. An evaluation of the total nutrients offered to the children showed an iron intake of just 4.0 mg/day. Baseline mean hemoglobin was  $9.4 \pm 2.6$  g/dl, and after three months, mean hemoglobin increased to  $13.2 \pm 0.2$  g/dl. Initial anemia prevalence was 73% and disappeared at three months post intervention. With the addition of bovine hemoglobin-fortified cookies to the children's diet, total iron intake increased to an average of 8.3 mg (83% of iron RDA – Recommended Daily Allowance) at a total cost of US\$ 0.50 per child, with no measurable side effects or taste alterations reported.

A project developed with 1500 children from daycare centers in the city of Barueri, Sao Paulo, using cookies and breads fortified with iron aminoquelato at a dose of 2 mg / day, showed reduced levels of anemia from 32% to 11% in a period of 2 months of intervention, with positive change for the weight / height and height / age (Fisberg et al., 1996). Giorgini et al. (2001) evaluated 89 preschool children during six months in a study using iron bis-glycinate chelate. Children received two sweet rolls twice daily each fortified with 2 mg iron bis-glycinate (4 mg/day) five days a week. At baseline, 28% of the children had hemoglobin levels less than 11.0 g/dl, and at six months end study, nine percent of the children continued to be anemic. Mean hemoglobin at baseline was 11.5 g/dl, and at end, 12.6 g/dl. Mean hemoglobin increased 1.1 g/dl in non-anemic children and 1.4 g/dl in anemic ones. At the start of the study, mean ferritin level was 11.3  $\mu$ g/l, and upon conclusion, mean ferritin increased significantly to 20.2  $\mu$ g/l. Anthropometric indicators for weight/age and height/age also increased significantly.

However, the problem of fortification of breads and crackers is that these foods are not consumed in sufficient quantities to meet the needs of infants, and often not even part of the food habits of this age group at highest risk for anemia. Despite the universal assumption that biscuits and sweet rolls are consumed by almost everyone, biscuits and sweet rolls consumption by infants, toddlers and school children are quite different. As a consequence, the fractional iron intake contribution would be too low in a flour-based fortification program for infants. But these two vehicles – biscuits and sweet rolls complement each other, resulting in a significant reduction of the population below the iron RDAs (Vellozo et al., 2003).

## 6. Iron fortification of potable drinking water

The addition of iron to potable drinking water is one alternative to the control and prevention of iron deficiency and anemia. This rather simple method can reach a large part of the Brazilian population at each level of the social-economic stratum by the use of drinking water on a daily basis. Drinking water, other than used for drinking, is commonly used for preparation of foods, which may contribute even more towards increasing iron ingestion (Ferreira et al., 1991).

Dutra de Oliveira et al. (1994) evaluated 31 preschool children aged two to six years enrolled in daycare facilities in Ribeirao Preto, Sao Paulo. During eight months, children consumed iron-fortified drinking water (20 mg Fe/Liter) which resulted in a significant decrease in the prevalence of anemia. At baseline, anemia prevalence was diagnosed in 58% of subjects. At four months 16% continued anemic, but at eight months post-study intervention anemia

virtually disappeared since anemia was present in only 3% of subjects. Mean hemoglobin levels at baseline ( $10.6 \pm 1.1$  g/dl) increased significantly to  $12.1 \pm 1.4$  g/dl at four months, and  $13 \pm 1.1$  g/dl at end study. In a later study, Dutra de Oliveira et al.(2002) studied low-income families during four months in which 21 families with children aged one to six years were divided into experimental and control groups. In the experimental group, family members consumed iron-fortified drinking water containing 10 mg of ferrous sulfate plus 60 mg of ascorbic acid per liter of water. The control group consumed their drinking water without the addition of iron or ascorbic acid. Results were very promising and showed that hemoglobin levels in children increased from  $10.9 \pm 1.1$  g/dl to  $11.7 \pm 1.1$  g/dl after four months of fortification intervention. Similar results were observed in the experimental adult group in which hemoglobin levels increased ( $12.9 \pm 1.7$  g/dl to  $13.7 \pm 1.7$  g/dl). Results for ferritin were also positive in the experimental group in which ferritin levels increased in children, and significantly in adults. According to the authors, the iron fortification of drinking water is an effective, feasible alternative and practical way to distribute iron to low-income families, is technically inexpensive and has the promising potential for the control and prevention of anemia in Brazil and in other countries.

In another study, 160 preschool children from eight municipal daycare facilities benefited from daily consumption of iron (12 g element iron/L) plus ascorbic acid (90 mg/L) prepared in 20-L plastic water jugs (Beinner et al., 2005). Mean Hb at baseline and after eight months of intervention increased significantly from  $11.8 \pm 1.3$  g/dl to  $12.4 \pm 0.93$  g/dl, respectively. The prevalence of iron deficiency determined by hemoglobin levels decreased from 43.2% to 21% at eight months post intervention. Significant ( $p < 0.05$ ) anthropometric growth indicators- weight/age, height/age and weight/height were also observed during the study. Fundamentally important to the success of this study was education of the targeted population, which resulted in behavior change and a greater awareness of the importance of combating iron deficiency and anemia by the use of iron-fortified drinking water.

The use of drinking water as a vehicle for the control and prevention of iron deficiency and anemia is an effective and efficient model, which can be used in targeting preschool children enrolled at daycare facilities, and/or at the household level, which will include all family members. Consumption of drinking water fortified with iron can contribute to increasing iron-intake to meet minimal Recommended Nutrient Intake (RNI) allowance of bioavailable iron acceptable to preschool children aged 6 to 59 months of age. Other than adding iron-concentrate to the appropriate number of liters of drinking water, it is easy to distribute and can be easily monitored.

In children attending daycare centers in Belo Horizonte city, southern of Brazil, a longitudinal study was conducted to evaluate the effectiveness of fortification of drinking water with iron and vitamin C in the reduction of the anemia as well as to identify the prevalence of anemia. It was evaluated 380 children aged six to 74 months. Since 55 did not participate in the second evaluation, a total of 312 children assessed before and at the end of the intervention. To study the identification of risk factors, it was evaluated only children under five years old, the group with the highest risk for anemia. A questionnaire was applied to parents or responsible for the children, containing information socioeconomic, maternal and related to the children's health. Anthropometric measurements (weight and height) and fingerstick blood samples occurred in two periods: before and after five months of fortification. Children were considered as anemic with hemoglobin  $< 11.0$  g / dl for the group aged 6 to 59 months, and values  $< 11.5$  g/dL for those aged 60 to 74 months. Multivariate analysis was performed to evaluate the association between these variables and anemia. The total number of children evaluated before and after

the fortification was 318, being 52.2% male, with average of  $45.4 \pm 15.8$  months. The prevalence of anemia decreased significantly from 29.3% before the fortification, to 7.9% at the end of the study ( $p < 0,001$ ). Considering the prevalence by age group, a reduction of 62.5%, 75% and 78.8% was found for children of 24 months, 24 to 48 months and  $> 48$  months, respectively. The hemoglobin median increased 10.2%: from 11.8 g/dL to 13 g/dL, with a significant increase in all age groups. There was improvement in height-for-age and weight-for-age, however, only the first measurement showed a significant difference. For the study of the risk factors of anemia, the prevalence of anemia in this population was 30.8%, and the prevalence was 71.1% in children aged  $\leq 24$  months. The risk factors of anemia were age  $\leq 24$  months (OR: 9.08 CI: 3.96 to 20.83), and height-for-age  $< -1$  z score (OR: 2.1, CI: 1.20 to 3.62). The fortification of water with iron and vitamin C significantly reduced the prevalence of anemia in children attending daycare centers, as well as it improved the nutritional status of them, being considered an important strategy to control this nutritional deficiency (Rocha, 2010)

## 7. Iron fortification of bean and rice

In southeastern state of São Paulo, Brazil, studies were carried out, during four months, to evaluate bean flour enriched with iron in 85 anemic children two to five years of age. Results demonstrated a non-significant increase in anthropometric measurements and a significant reduction in the prevalence of anemia, which at baseline, was 13%, and at end study, anemia had disappeared in subjects that had received the iron-fortified bean flour (Fisberg et al., 2003). Unfortunately, milled bean flour represents a greater cost burden, and in addition, is not widely consumed throughout Brazil.

Rice is another alternative for food fortification. One study was conducted in four nurseries in Rio de Janeiro (RJ), with children in the intervention group ( $n = 180$ ) attending two nurseries and the control group ( $n = 174$ ) in the other two nurseries. It was observed an increase in hemoglobin concentration in both groups, with the reduction in the prevalence of anemia in the intervention group was 37.8% to 23.3% and for the control group was 45.4% for 33, 3%, with no difference in reduction between the groups. According to the authors, the total amount of iron available was not sufficient to achieve more significant results in the intervention group, after four months of study (Bagni et al., 2009). The other study was conducted with families in the metropolitan area of Belo Horizonte. A group of 84 children received iron-fortified rice (23 mg Fe / day) and another group received ferrous sulfate (25 g Fe / L). After five months of intervention, there was a reduction in the prevalence of anemia in both groups, with an initial prevalence of 100% in both groups, decreasing to 61.9% for the group receiving the fortified rice and 85.6% for the group receiving ferrous sulfate, with a significant difference between groups (Beinner et al., 2009). Regarding rice, more studies are needed to evaluate the timing and dose required fortification of that vehicle, to achieve preventive effects and / or significant curative as well as assess the effect of simultaneous use with other supplements containing iron

## 8. Other iron fortified foods

Orange juice fortification studies shown improvement in childhood anemia. In ongoing studies with iron fortification of foods, De Paula & Fisberg (2001) evaluated the use of 20 g of iron fortified sugar added to orange juice offered to 93 preschool children during six months. Children were divided into two groups: group 1 received 10 mg of iron per kilo of sugar, and group 2 received 100 mg of iron per kilo of sugar, both in the form of ferrous tris-



glycinate. Anemia prevalence in both groups evaluated at baseline was 38.1% and 29.4%, respectively. At six months post study intervention, anemia prevalence in both groups decreased to 19.7% and 19.6%, respectively ( $p = 0.01$ ). Mean hemoglobin levels increased to 0.4 g/dl; in anemic children alone, mean Hb increased greatly to 1.3 g/dl and 1.5 g/dl in groups 1 and 2, respectively ( $p < 0.001$ ). According to ferritin results, there was a positive trend towards normalization of ferritin values in iron-deficient children. It was suggested, in terms of cost, that use of 10 mg iron/Kg be used when compared with 100 mg/Kg, as same results were observed.

In yet another study using orange juice as an iron vehicle, Almeida et al. (2003) evaluated iron fortification of this widely produced fruit rich in vitamin C, which greatly facilitates iron absorption. Fifty preschool children consumed orange juice with iron (10 mg ferrous sulfate per 100 ml of concentrated orange juice) twice daily during four months. Anemia prevalence decreased from 60% to 20% at end study, and mean hemoglobin level increased from  $10.5 \pm 1.7$  to  $11.6 \pm 1.1$  g/dl ( $p = 0.00$ ). The use of iron fortified orange juice is a promising strategy as a complimentary vehicle for ingestion of iron in children. Orange juice is widely consumed by all levels of the social strata in Brazil. An iron compound can be added during processing without provoking organoleptic changes (i.e., color, flavor, and consistency), and even allow for much higher quantities of iron- from 3 to 10 times more- than in other targeted or mandatory foods. The added cost can be absorbed through advertising and processing.

The manioc flour enriched with ferrous bis-glycinate was studied during four months in 80 preschool children enrolled in a philanthropic institution in the city of Manaus. Anemia prevalence decreased significantly from 22.7% to 8% after four months of intervention ( $p < 0.05$ ). According to the authors, mandioca flour is widely consumed in the North region of the country and can be considered a promising food vehicle in the control and prevention of iron deficiency and anemia (Tuma et al., 2003)

Studies on fortification showed a positive response, both in relation to acceptance of fortified food, and prevention, as in the recovery of hemoglobin levels in both groups (Hertrampf, 1990; Torres et al., 1995; Vitolo et al., 1998). The food industries have used the enrichment of their products as a commercial appeal, focused on creating a quality attribute to further enhance the marketing of their products. However, there is no data in Brazil to assess the impact of these foods, fortified voluntarily by industry, in the prevalence of anemia.

## 9. Conclusion

Studies on iron fortification of foods, over the last twenty years, have shown promising results in the control and prevention of iron deficiency and anemia in infant and child populations. Unfortunately, only a small number of efficacy and effectiveness trails of iron fortification of foods and liquids conducted in Brazil have been published. Researchers have used various types of food vehicles as well as different iron compounds in attempt to reduce nutritional deficiency, particularly an iron deficiency.

The high prevalence of iron deficiency and anemia in infancy in most regions of Brazil have called attention to an inadequate nutrition making this a serious public health problem leading to eventual losses in terms of future growth and productivity at all stages of human development. State and federal governmental health agencies must move forward to

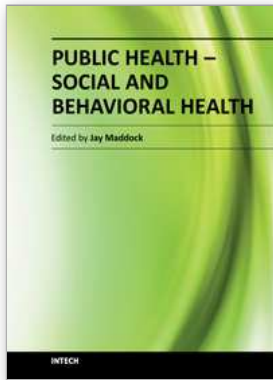
prioritize national nutrition agenda that will draft mandatory fortification of food staples for mass consumption. Finally, fortified food is made available to vulnerable populations when industry is motivated to develop the logistics needed to fortify their products and when government is motivated to change policy requiring fortification.

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Human behavior accounts for the majority of morbidity and premature mortality throughout the world. This book explores several areas of human behavior including physical activity, nutrition and food, addictive substances, gun violence, sexual transmitted diseases and more. Several cutting edge methods are also examined including empowering nurses, community based participatory research and nature therapy. Less well known public health topics including human trafficking, tuberculosis control in prisons and public health issues in the deaf community are also covered. The authors come from around the world to describe issues that are both of local and worldwide importance to protect and preserve the health of populations. This book demonstrates the scope and some of the solutions to addressing today's most pressing public health issues.

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Phone: +86-21-62489820  
Fax: +86-21-62489821

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