LESSONS LEARNED WITH IRON FORTIFICATION IN CENTRAL AMERICA.

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Iron Fortification: Where are we in terms of iron compounds?
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INTRODUCTION (Transparency 1)

The countries of Central America have been pioneers in the developing world about food fortification initiatives. Thus, salt fortification with iodine was introduced since the late 40´s and 50´s; sugar fortification with vitamin A is carried out as national programs in Guatemala, Honduras, El Salvador and Nicaragua; and cereal fortification with iron and vitamins of the complex B was introduced since 40´s and 60´s. Salt and sugar fortification have been carefully characterized and evaluated, and the impact of these two interventions to prevent and to control iodine and vitamin A deficiency, respectively, is out of any doubt. However, the same has not happen with cereal fortification, and until know the effect of this intervention is unknown. Nevertheless, some lessons can be extracted from our experience during the last 10 years, and I will present them in this talk.

EVOLUTION OF WHEAT FLOUR FORTIFICATION IN CENTRAL AMERICA (Transparency 2)

Central America introduced fortification of wheat flour in the period between the late 40´s to 60´s following the technical requirements for this product enacted by the United States and Canada. In 1992 INCAP, recognizing that Iron Deficiency Anemia (IDA) was still a public health problem in all countries of the region, reason by which launched an initiative to improve the enrichment characteristics of this food. Guatemala passed legislation –still in effect- to raise and to change the iron compound from elemental iron to ferrous sulfate. This suggestion was made based on the successful case of Chile with wheat flour fortification. However, under the Guatemalan weather and current bakery practices, the introduction of ferrous sulfate caused green and black spots in breads. This condition prompted the return to elemental iron. However, in this occasion it was mandatory to use iron of small particle size (45 μm or less). It was expected to obtain a slightly inferior effect as ferrous sulfate. We just recently learned that the iron type was not hydrogen reduced but the

atomized and water-reduced compound, whose bioavailable properties have not been established yet. Together with the increment of iron content, folic acid was introduced too, and Guatemala and El Salvador were among the first countries of the world to recognize the importance of this nutrient in food fortification. In order to favor the bioavailability of iron, calcium –a reported competitor of the mineral absorption mechanisms- was eliminated as a fortificant of wheat flour.

In the second half of the 90´s, the policies of economical globalization started to influence the interchange of products and services in the Central American region, and therefore it was a need to harmonize technical requirement of food fortification programs in order to favor their survival under such conditions. Thus, the "new" recommendations for wheat flour fortification were disseminated in the rest of the Central American countries. In this occasion, a higher level of folic acid, matching the world most current recommendations, was suggested. Now, all Central American countries, with the exception of Guatemala, are adding fortification levels of elemental iron and folic acid. Guatemala still uses the specification of 1993. It is important to point out here, that in the new legislation was introduced a note to make possible the change of the type of iron for another of better bioavailability and similar technological properties, once this compound be established.

FORTIFICATION OF NIXTAMALIZED CORN-FLOUR IN CENTRAL AMERICA (Transparency 3)

Tortilla made with nixtamalized corn-flour (NCF) is the main staple of the countries of the North of Central America. Therefore, the industrially produced NCF is potentially a good vehicle to bring micronutrient to consumers. Fortification of this food started since the 70´s, despite that at that time only a very small portion of the population was consuming industrially produced flour. Fortification levels were similar to those of wheat flour. Recently, Costa Rica, even though being a country where the corn consumption is low, passes legislation to fortify NCF, following the suggested levels of micronutrients for wheat flour, but requesting 22 mg/kg iron from ferrous bisglycinate. This decision was taken based on the supposedly better bioavailability of this compound over others. The company Maseca supported and adopted this decision as a means to improve the public appealing of its product, and introduced fortification NCF in all Central American countries, independently to any governmental motivation. However, soon they found that the flour color changed, reason by which only the product destined to supermarkets is being fortified but not that aimed to industrial use (i.e. tortilla producers). The latter use is the most important from an epidemiological point of view. This case illustrates that in the actual world, a practice in one country is easily diffused in the neighbors regardless a decision by public health authorities.

FORTIFICATION OF COMPOSITE FLOURS IN GUATEMALA (Transparency 4)

One of the main products of INCAP´s research during the 60´s was the developing of complementary foods made with corn and other ingredients, looking for the complementation of the amino acid composition of corn protein. The most famous product is INCAPARINA, which has been in the Guatemalan market during almost 20 years. Similar products, replacing the cottonseed flour of INCAPARINA by soy flour were simultaneously designed and evaluated, but they were commercially introduced until the 90´s. All these products are enriched with micronutrients in amounts approximately 4 times larger than in wheat and corn flours. Iron type was initially elemental, but it has been recently changed to ferrous fumarate. This example shows that these products accept large contents of micronutrients without sensorial limitations as in the case of simple cereal flours, and therefore the composite flours should be considered as good candidates to bring micronutrients to populations at risk.

NUTRITIONAL ANEMIA IN CENTRAL AMERICA (Transparency 5)

In spite of all efforts in food fortification with iron, the Central American population is still suffering of IDA. There are many reasons to explain this situation, including of course that the implemented fortification programs have been unsuccessful. It is obvious that large sectors of the population are not consuming sufficient amounts of the fortified foods, but also it might be that the bioavailability of iron in those foods is low. The latter subject had received little attention until recently. That means, that iron fortification was introduced without the companion of coupling systems to check for its efficacy and effectiveness. This situation might be also common for other countries.

RECENT EFFORTS TO IMPROVE THE QUALITY OF THE IRON FOOD FORTIFICATION PROGRAMS

Aware of the situation, during the last 3 years, we initiated in INCAP a series of studies aimed to optimize the fortification programs. We analyze the technological compatibility of different iron compounds, reported in the literature as having good bioavailability, as fortificants of wheat and nixtamalized corn flours. The idea was to determine the maximum load of iron that these foods could tolerate without producing undesirable sensorial changes.

In wheat flour **(Transparency 6)**, we found that both ferrous sulfate and FeNaEDTA or EDTA-alone could not be used because dough viscosity and specific volume of bread were badly affected. Ferrous fumarate behaved adequately up to 60 mg/kg and ferrous bisglycinate up to 20 mg/kg.

Similar work in corn nixtamalized flour **(Transparency 7)** suggested that only ferrous fumarate up to 30 mg Fe/kg did not change the color, odor and flavor of the tortilla. Ulterior work indicated that 15 mg Fe/kg as ferrous bisglycinate and 10 mg Fe/kg as FeNaEDTA may be also compatible with NCF, but these results need further confirmation.

Another food that is a candidate to be fortified with iron is powder milk in Costa Rica. It has been planned that milk will be fortified with ferrous bisglycinate at a level of 50 mg/kg as iron.

Based on the technological compatibility, estimated bioavailability and relative cost, we have reached the conclusion that currently the most suitable iron compound to fortify wheat and corn nixtamalized flours is ferrous fumarate. A research carried out by the Technological Institute of Zurich, with support from SUSTAIN and INCAP´s collaboration, determined that about 5% of iron from ferrous fumarate in NCF is absorbed. Accordingly, we have prepared a new proposal of nutritional requirements of these foods **(Transparency 8)**. With this proposal, wheat and corn-nixtamalized flours would become good and excellent sources of iron, respectively, based on the actual consumption patterns. However, there is still a need to evaluate the biological efficacy of the fortified nixtamalized-corn flour with ferrous fumarate. It is almost certain that the consumption of products made with fortified wheat flour would help to alleviate iron deficiency, but alone probably would not have a measurable impact. A field efficacy trial of this product might be adequate only if the daily consumption of wheat flour were at least 120 g. This condition does not happen in Central America. The theoretical calculations that were done emphasize the need to fortify other foods with iron and/or to introduce other complementary strategies, aimed to prevent IDA. In Central America, differently to other food fortification programs with other micronutrients, it is difficult to place all confidence in food fortification of a few commodities to solve the problem of IDA.

It is important to point out that both flours, once they are fortified, become excellent sources of vitamins of the complex B, including folic acid. The importance of these fortified flours in the improvement of the status of these other micronutrients needs to be evaluated too.

One good advantage of the new INCAP proposal is the use of the same micronutrient premix to fortify wheat and corn-nixtamalized flours. The proportion of the addition of the premix changes in these flours, being 1.8 larger for wheat flour. This approach might reduce the cost of fortification, allowing the competition among several suppliers of the premix. That could be very important if several countries adopt similar fortification specifications. On the other hand, it is important to point out here that with the use of this premix, and taking in consideration the intrinsic nutritional composition of wheat flour, the

micronutrient levels of the fortified flour would agree with the current legislation. Therefore, efforts and changes in this regard may be unnecessary.

In summary, Central America has had a large experience in food fortification with iron. Mostly has been in technological feasibility and in theoretical estimations of the probable effects. There is a need to carry out efficacy field trails of the potential more efficacious interventions, as well as to introduce permanent monitoring systems to follow the evolution of IDA in response to the several strategies that are being introduced.

LESSONS LEARNED WITH IRON FORTIFICATION IN CENTRAL AMERICA

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EVOLUTION OF WHEAT FLOUR FORTIFICATION IN CENTRAL AMERICA (mg/kg)

NUTRIENT	1948-1960	1993-1996	1998 – (Minimum levels)
Iron (elemental)	28.7	55-65*	55-60
B-1	4.4	4.0-6.0	4.0-6.0
B-2	2.6	2.5-3.5	2.5-4.0
Niacin	35.2	35-40	45-55
Folic Acid	---	0.35-0.45	1.3-1.5
Calcium	1,100.0	---	---

*Started with ferrous sulfate but sensorial changes obligated to return to elemental iron (atomized, 350 Mesh, < 45 µm).

FORTIFICATION OF NIXTAMALIZED CORN-FLOUR (NFC) IN CENTRAL AMERICA (mg/kg)

NUTRIENT	GUATEMALA (Torti-ya; 1970's)	COSTA RICA (Maseca; 1999)
Iron	30.9 (elemental)	22.0 (Bisglycinate)
B-1	4.8	4.0
B-2	2.8	2.5
Niacin	35.3	45.0
Folic acid	---	1.3

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FORTIFICATION OF COMPOSITE FLOURS IN GUATEMALA (mg/kg)

	INCAPARINA	BIENESTARINA INNOVARINA
Main ingredients		
Corn flour	60%	70%
Cottonseed flour	40%	---
Soybean flour	---	30%
Micronutrients		
Iron (elemental)*	112-180	200
B-1	17	11-22
B-2	10	12-20
Niacin	136	142-205
Vitamin A	12.0-13.5 4.5**	13.5-15.0 4.5**
Folic Acid	3.3**	3.3**
Vit. B-12	0.002**	0.002**
Zinc	1.2**	1.2**

*Recently changed to ferrous fumarate
**Proposed

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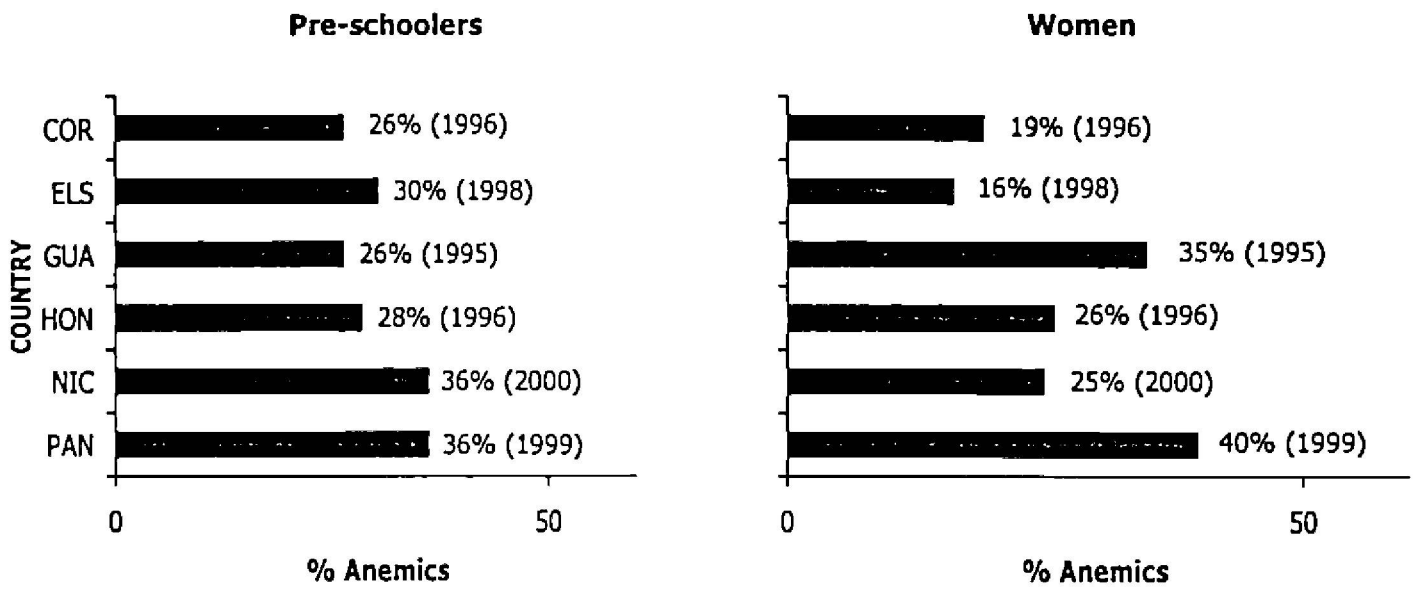
NUTRITIONAL ANEMIA IN CENTRAL AMERICA



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TECHNOLOGICAL COMPATIBILITY OF IRON COMPOUNDS AS FORTIFICANTS OF WHEAT FLOUR*

	CHARACTERISTICS (Similar cases to the fortified control with 60 mg/kg elemental- iron)			
COMPOUND	**COLOR**	**PEROXIDE FORMATION**	**DOUGH VISCOSITY**	**SPECIFIC VOLUME OF BREAD**
Ferrous fumarate (30-60)	30-60 mg/kg	30-60 mg/kg	30-60 mg/kg	30 – **60** mg/kg
Ferrous bisglycinate (15-30)	15-30 mg/kg	15-30 mg/kg	15-30 mg/kg	15 – **20** mg/kg
FeNaEDTA (15-30)	15-30 mg/kg	15-30 mg/kg	---	---
$FeSO_4$ (30-60)	30-60 mg/kg	---	---	---

*Data from Food Technology and Agroindustry Unit of INCAP.

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TECHNOLOGICAL COMPATIBILITY OF IRON COMPOUNDS AS FORTIFICANTS OF NIXTAMALIZED CORN FLOUR*

	TORTILLA CHARACTERISTICS (Similar cases to the unfortified control)		
COMPOUNDS	**ODOR**	**FLAVOR**	**COLOR**
Ferrous fumarate (22-30)	22 – **30** mg/kg	22 – **30** mg/kg	22 – **30** mg/kg
Ferrous bisglycinate (22-30)	22 - 30 mg/kg	**22** mg/kg	15 mg/kg**
FeNaEDTA (22-30)	22 - 30 mg/kg	**22** mg/kg	10 mg/kg**

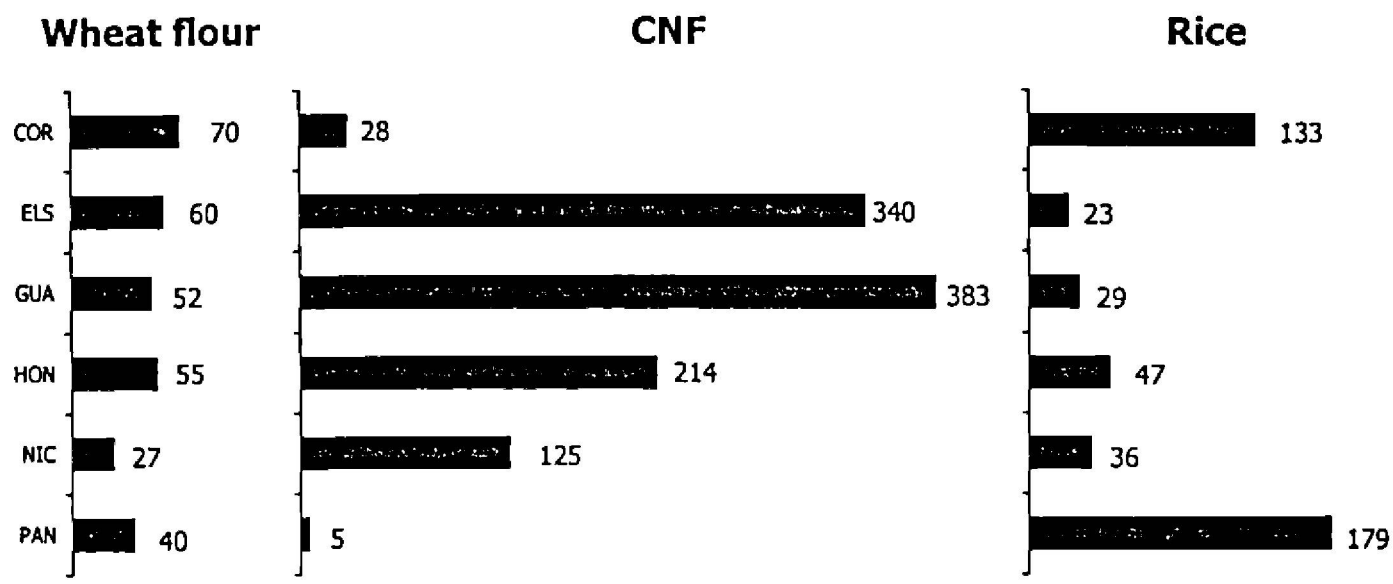
*Data from Food Technology and Agroindustry Unit of INCAP
**Preliminar, subjected to confirmation

NEW PROPOSAL FOR WHEAT AND NCF FORTIFICATION IN CENTRAL AMERICA

NUTRIENT	WHEAT FLOUR		NCF		%DAILY REFERENCE VALUE	
	Addition*	Total (mg/kg)	Addition*	Total (mg/kg)	Wheat flour (60g)	NCF (255 g)
Iron (as ferrous fumarate)	45	55	25**	54	16.5	68.8
B-1	5.4	6.2	3.3	6.1	31.0	130.0
B-2	3.6	4.2	2.0	2.5	19.4	49.0
Niacin	45	55	25	49	20.6	78.1
Folic acid	1.8	1.8	1.0	1.0	27.0	63.7
Calcium	---	160	---	800***	0.7	15.7

Notes: *Same micronutrient premix for both flours, but changing the proportion.
**It may be replaced by 15 mg Fe/kg as ferrous bisglycinate or 10 mg Fe/kg as FeNaEDTA.
***Artesanal product has 1,200-1,600 mg/kg.

CEREAL CONSUMPTION PATTERN IN CENTRAL AMERICA (g/day)



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