

## Advances in Iron Fortification

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# iron fortification is on the move

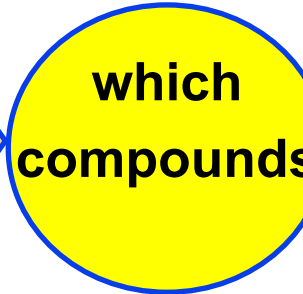
(ILSI, SUSTAIN, PAHO, WHO, INAGC, IDPAS.....GAIN)

**SUSTAIN  
Monterrey 2000**

usefulness of elemental iron powders,  
guidelines for the fortification of  
cereal staples (2001)

**PAHO  
Washington 2001**

iron compounds for food fortification,  
guidelines for Latin America and the  
Caribbean (wheat, maize flours) (2002)



which  
compounds

**WHO 2001  
Food  
Fortification  
Task Force**

guidelines for food fortification (expected 2003)  
at-risk nutrients, major vehicles,  
which compounds, how much, advocacy,  
cost- benefit, monitoring, evaluation, regulation

**INAGC  
Task Force 2002**

level of iron fortification - pending

## Guidelines PAHO (2002):

### Recommended iron compounds for wheat and maize fortification

wheat flour,  
degermed  
maize flour

- ferrous sulfate, encapsulated ferrous sulfate
- ferrous fumarate, encapsulated fumarate
- electrolytic iron (2xFS)

nixtamalized  
maize flour

- NaFeEDTA
- ferrous fumarate, encapsulated fumarate or sulfate (2x)

complementary  
foods  
(targeted  
fortification)

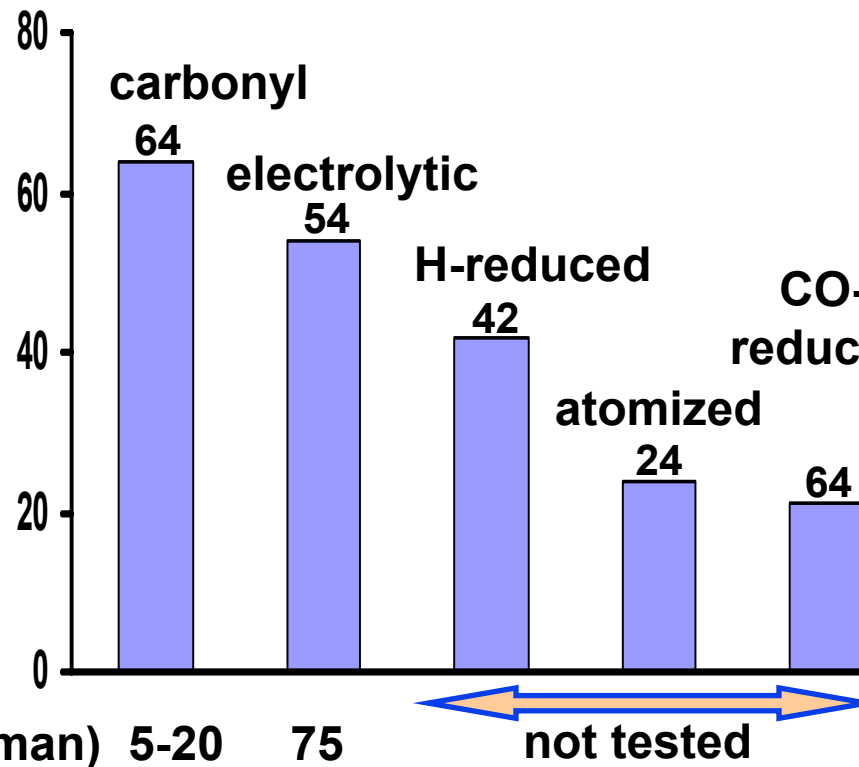
- ferrous sulfate, ferrous fumarate
- ascorbic acid (2:1 molar ratio AA:Fe)

**other elemental iron compounds (H-reduced, CO-reduced, atomized, carbonyl are not recommended at the present time**

# SUSTAIN elemental iron powder evaluations

- ★ current commercial powders have similar bioavailability in rats to powders tested in 1970-80
- ★ planned human efficacy studies (2003)
  - Morocco: FS vs. 2x electrolytic in wheat flour snacks fed to school children
  - Thailand: FS vs. carbonyl vs. H-reduced in wheat/rice snacks fed to young women
  - USDA: Hb repletion in Fe deficient (phlebotomized) human subjects

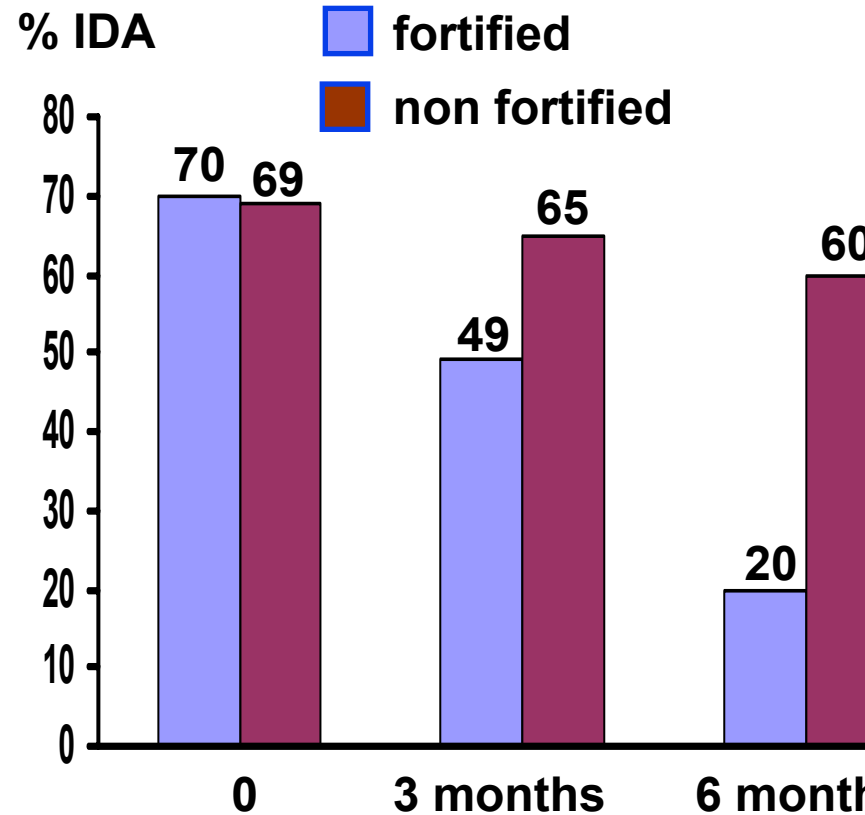
relative bioavailability in rats  
(Swain & Hunt 2002)



# NaFeEDTA is a highly efficacious fortificant in fish sauce and soy sauce

- ★ Vietnam efficacy study  
2 groups of ca. 75 young anemic women fed rice or noodle snack with 10ml fish sauce 6 days/week for 6 months
- ★ sauce provided 10mg Fe/d as NaFeEDTA or no iron
- ★ monitored Hb, serum ferritin, transferrin receptor  
(IDA = low Hb plus low SF or high TfR)

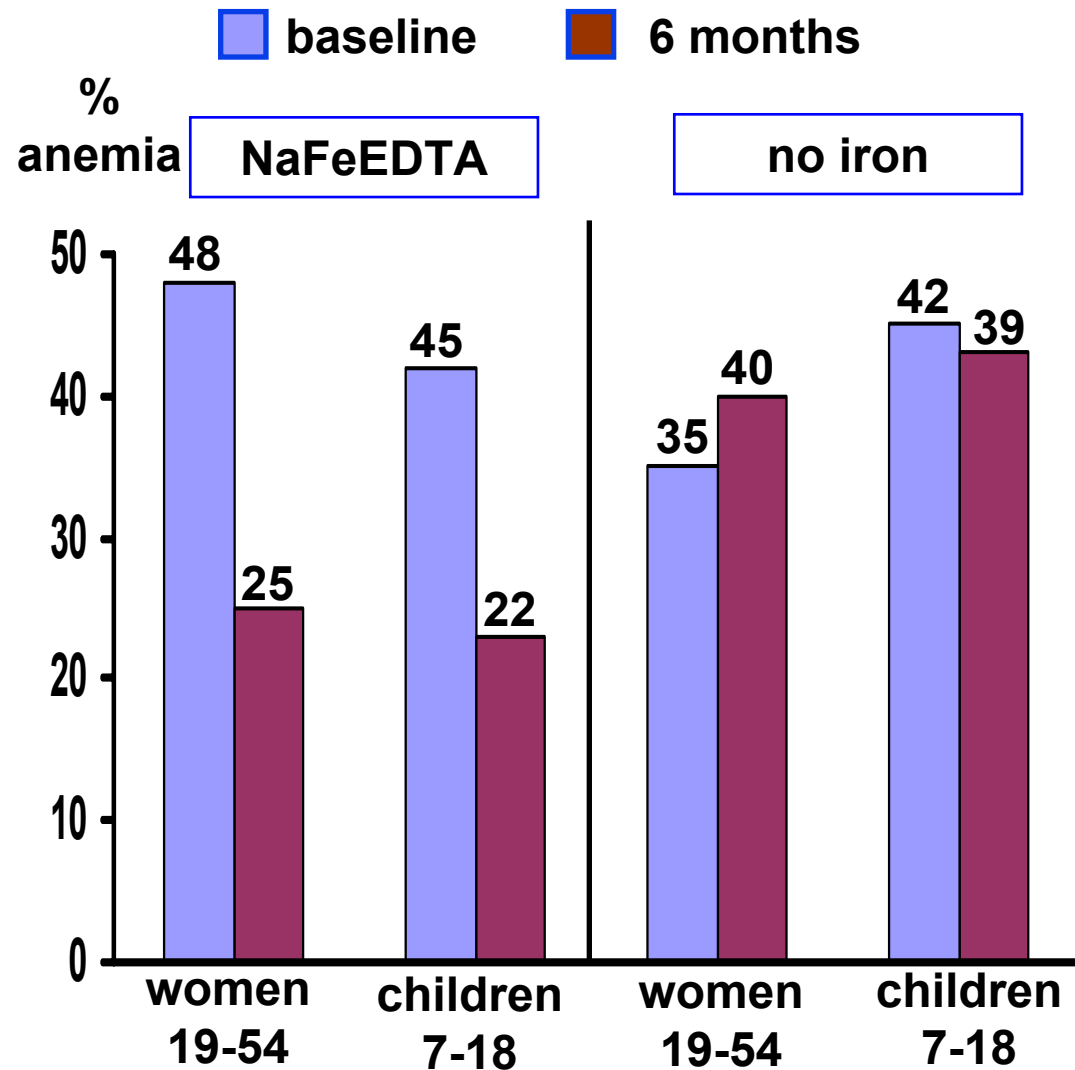
improved iron status with  
iron fortified fish sauce  
(Thuy et al 2002)



# Chinese studies with NaFeEDTA fortified soy sauce

(compiled by Mannar & Boy 2002)

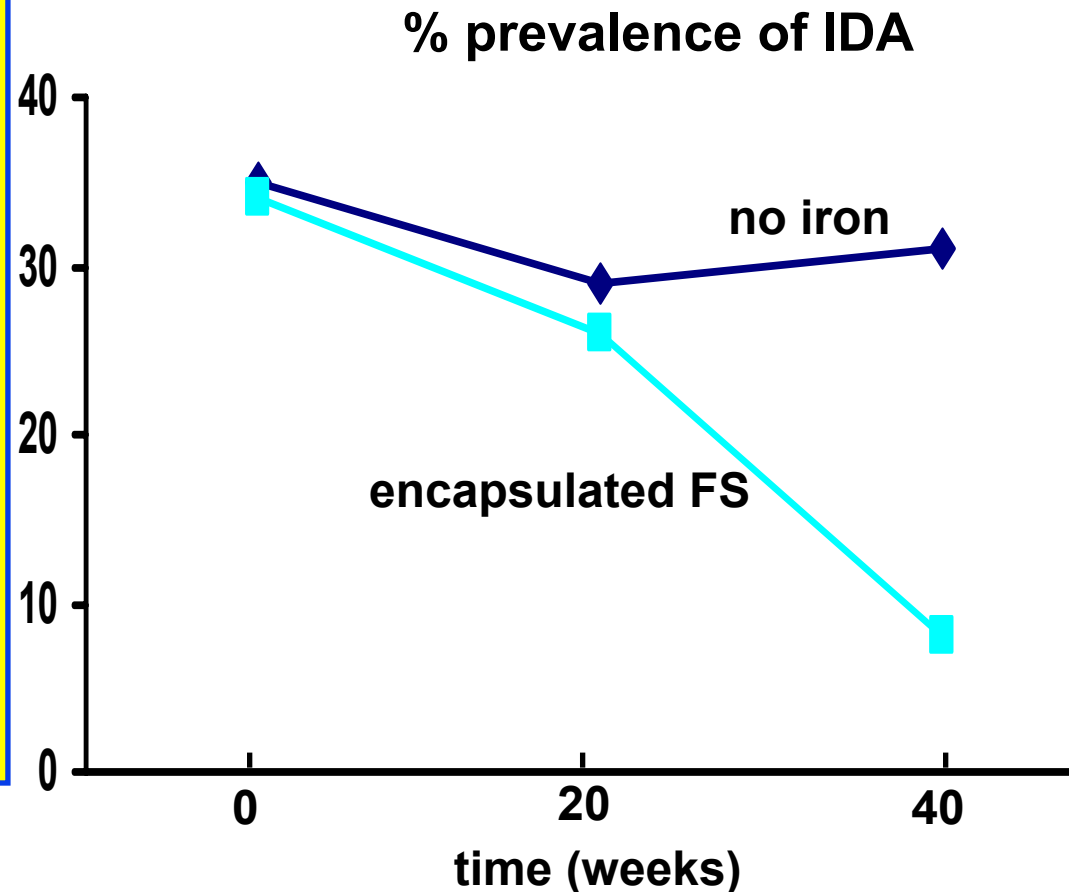
- ★ effectiveness study in population of ca. 10'000 subjects with ca. 30% anemia
- ★ soy sauce provided to households contained either 5mg Fe/d as NaFeEDTA or no iron
- ★ monitored Hb, SF ZPP at 6 months



# iron fortified salt improves iron status in iron deficient Moroccan school children

(Zimmermann et al. 2003)

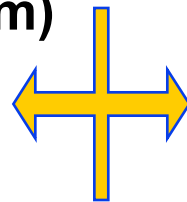
- ★ salt containing 25 $\mu$ g iodine/g and either no iron or 1mgFe/g as encapsulated ferrous sulfate provided to households
- ★ salt added to normal diet (bread, fava beans)
- ★ iron status (Hb, SF, TfR, ZPP) monitored in ca. 380 school children (6-15yrs) consuming 7-12g salt/d



# encapsulated iron compounds can prevent sensory changes with no changes in bioavailability

◆ ferrous sulfate and ferrous fumarate can be encapsulated with protective coatings

hydrogenated oils (soy, palm)  
ethyl cellulose  
maltodextrin  
mono- and diglycerides  
edible waxes



relative iron absorption is little changed in rats



- ▶ prevent fat oxidation reactions in stored cereal-based complementary food
- ▶ some compounds prevent color changes and iodine losses during storage of some salts

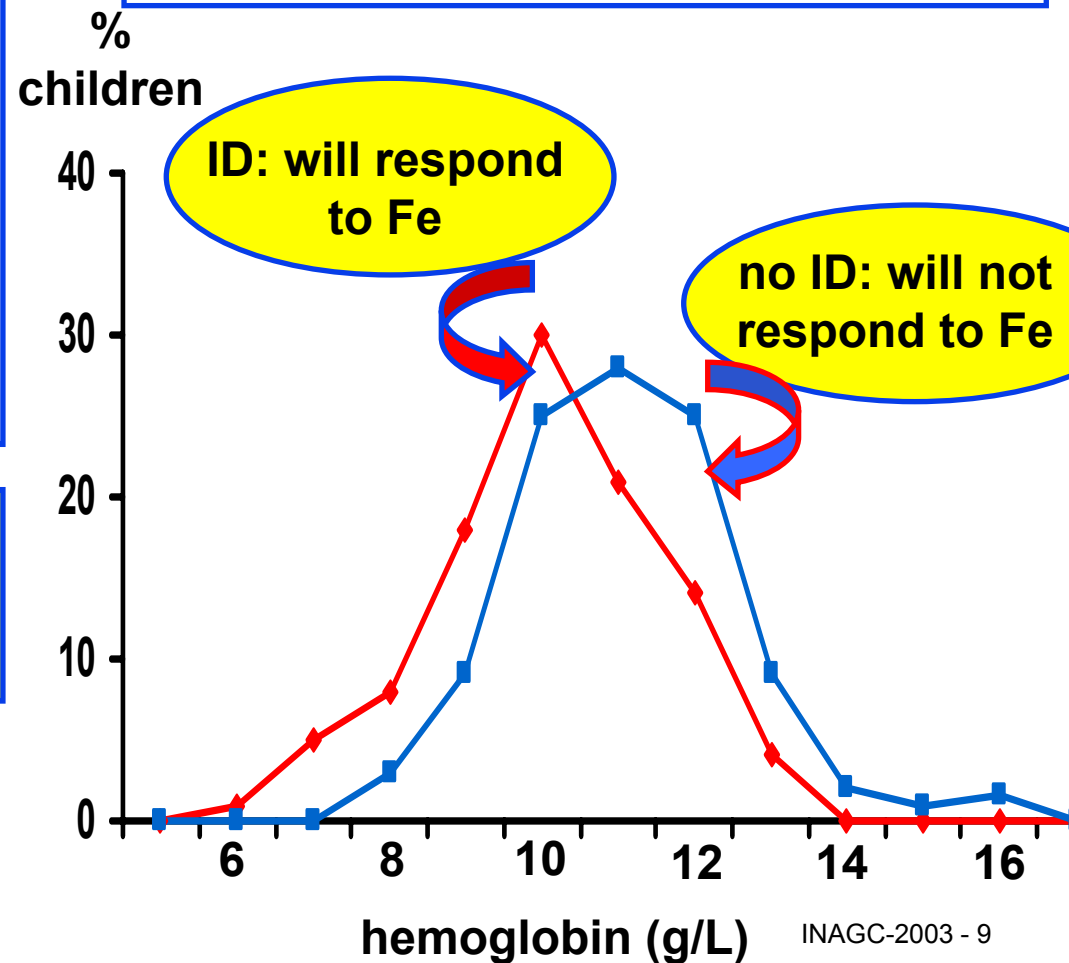
◆ capsule removed on cooking or heat processing  
◆ 3- 4 times cost of ferrous sulfate per mg Fe

# some keys to the recent success of iron fortification efficacy studies

- ★ foods provided 5-10mg Fe/d as highly bioavailable iron
- ★ rigorous planning and control of studies: monitoring IDA: iron status as well as Hb

★ all anemia is not due to ID

Hb distribution in Ivorian children (6-15yrs) with and without ID

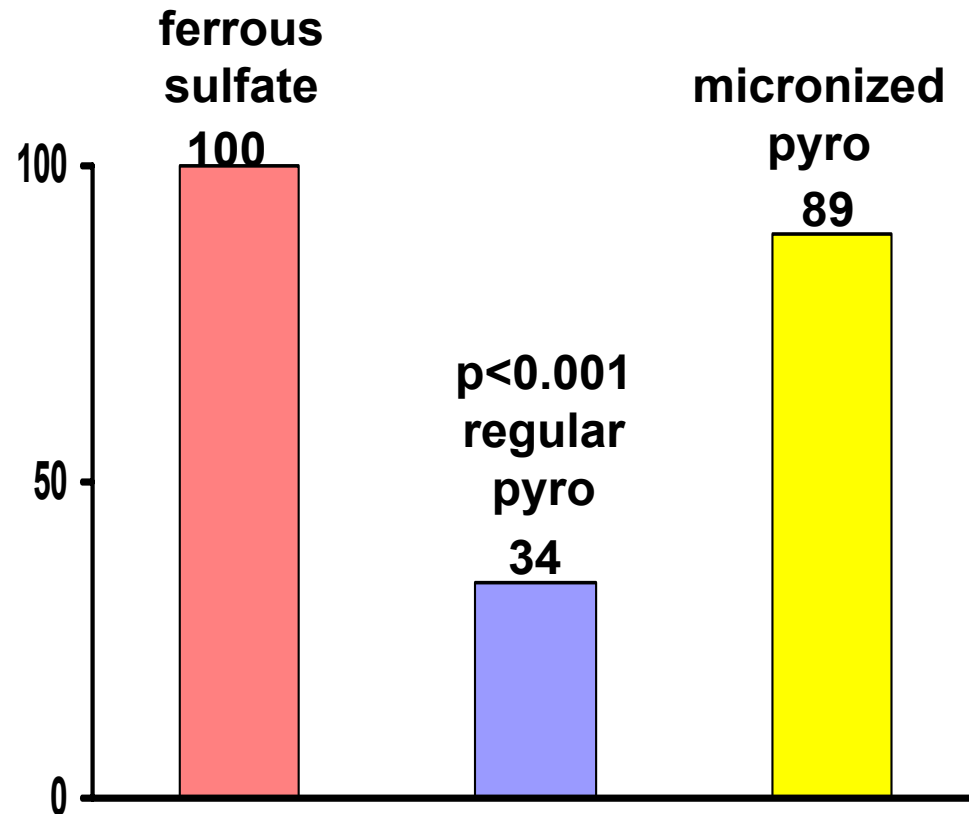


# recent development: micronization of poorly soluble iron compounds to improve bioavailability

- ★ abs. increased 3 fold by decreasing particle size of ferric pyrophosphate from ca. 10 $\mu$ m to 0.5 $\mu$ m (SunActive Fe: mixed with emulsifiers/dispersable in liquid)
- ★ stable isotope absorption study in adult women consuming infant cereal or yoghurt drink

- ★ no color changes or iodine losses in salt stored in Morocco or Côte d'Ivoire
- ★ potential for extruded rice grains and bouillon cubes

**% relative bioavailability of micronized ferric pyrophosphate**  
(Fidler et al. unpubl.)



# Is ferrous fumarate absorbed as well in young children as in adults?

- ★ guidelines recommend ferrous fumarate for fortification of complementary foods
- ★ same relative bioavailability as ferrous sulfate in adults
- ★ only 35% as well absorbed by Bangladeshi children (3-5yrs) with IDA, H.pylori-free
- ★ lower gastric acid secretion infant vs. adult healthy vs. multiple micronutrient deficiencies/infections

(Davidsson et al 2001, Fidler et al 2003)

	% iron absorption from ferrous fumarate	
	Bangladeshi children	female Swiss adults
<sup>57</sup> ferrous fumarate	5.4%	3.1%
<sup>58</sup> ferrous sulfate	15.6%	3.0%
RBV	(35)	(95)

# Iron fortification is on the move

- ★ Several recent studies demonstrated that iron fortified foods improve iron status.
- ★ New guidelines (PAHO/WHO), potential finance (GAIN)

## NEED TO:

- ★ Demonstrate efficacy of wheat and maize flour fortification; explore encapsulated ferrous sulfate; clear advice on elemental iron powders.
- ★ Improve encapsulation technology for salt fortification.
- ★ Evaluate influence of age, micronutrient status on absorption of fortification iron.