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**Efficacy and effectiveness of iron in
complementary foods, rice and wheat flour**

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Iron Fortification Update (2007)

- ◆ WHO Guidelines published 2006. Recommend iron compounds for different vehicles and provide a method for defining fortification level.
- ◆ Recent efficacy studies which have (to a large extent) followed the Guidelines have demonstrated efficacy of iron in:

cereal based complementary foods

rice

wheat flour

maize flour.

milk

salt

soy and fish

sauce



No true effectiveness studies have been published.

Suggested iron compounds for complementary foods, rice and wheat flour (WHO 2006)

food vehicle	iron compound
cereal based complementary foods	ferrous sulfate, encapsulated ferrous sulfate, ferrous fumarate, electrolytic Fe (2x amount), <i>all with ascorbic acid at $\geq 2:1$ molar ratio to Fe</i>
rice	ferric pyrophosphate (2x amount)
low extraction wheat flour, degermed maize flour	dry ferrous sulfate, ferrous fumarate, electrolytic Fe (2x amount), encapsulated ferrous sulfate or fumarate
high extraction wheat flour, maize flour	NaFeEDTA, ferrous fumarate (2x amount), encapsulated ferrous sulfate or fumarate (2x amount)

Defining the iron fortification level (WHO 2006)

- ◆ full probability approach (methods, tables provided) as opposed to EAR set point method for other micronutrients
- ◆ National programmes: provide all iron lacking in the diet in one or more food vehicles

amount lacking = requirement - current intake
fortification level depends on vehicle consumption and expected Fe absorption

- ◆ Industrial foods:
 - provide a defined proportion of Fe needs
 - must take into account other Fe fortified foods and UL

Defining the fortification levels

CDC/WHO recommendations for flour fortification (Cuernavaca 2004)

		flour consumption	
		> 200 g/d	< 200 g/d
white wheat flour (<0.8 % ash)	dried ferrous sulfate	30 ppm	45 ppm
	ferrous fumarate	30 ppm	45 ppm
	electrolytic Fe	60 ppm	90 ppm
high extraction wheat flour	NaFeEDTA	30 ppm	(30 ppm)

Ferrous fumarate fortified maize-based complementary food

improves iron status of South African infants (Faber et al 2005)

- 6 mo randomized, controlled efficacy study in 2x ca. 150 6-12 mo infants (daily iron intake 3mg/d)
- fed daily 2x 25g sachets maize meal + 125ml milk/water with 100% RDA; Fe, Zn, B vits, Se, Cu, β -carotene (vit A)
- test group received 11mg Fe/d as ferrous fumarate with 56 mg ascorbic acid (1.6:1 molar ratio)

	baseline	6 mo	
Hb g/dL			
control	11.1	11.0	
iron fortified	11.1	11.9	p < 0.001
% anemia			
iron fortified	45	17	p < 0.001
serum ferritin μ g/L			
control	6.8	6.5	>0.001
iron fortified	8.7	15.8	p < 0.001

NaFeEDTA may be more appropriate but problem with ADI (Wreesman)

could also consider ferrous gluconate (Shamah-Levy)

Ferric pyrophosphate fortified rice improves iron status of Indian school children (Moretti et al 2006)

- ◇ randomized, double blind controlled study in 2x 90 4-14 yr old Indian children with ID
- ◇ iron fortified extruded artificial rice grains mixed 1:50 with normal rice fed 6 times/week for 7 mo
- ◇ 20mg Fe/d as ground ferric pyrophosphate (RBV 50) provided

	baseline	7 mo	
serum ferritin $\mu\text{g/L}$			
control	15	18	p < 0.001
iron fortified	17	26	
transferrin receptor mg/L			
control	8.7	7.2	p > 0.01
iron fortified	9.2	6.1	
body iron status mg Fe/kg BW			
control	0.9	2.0	p < 0.05
iron fortified	1.2	4.1	

Further studies confirmed usefulness of iron fortified rice

- ◆ Angeles-Agdeppen et al
micronized dispersible ferric pyrophosphate or ferrous sulfate in extruded rice premix reduced anemia in anemic Philippine 7-8 yr school children
- ◆ when fed 5d/week over 6 mo
- Hotz et al
MDFP in Ultra rice (cold extrusion) premix improves iron status (Hb, SF) of young women when fed 5d/week over 6 mo

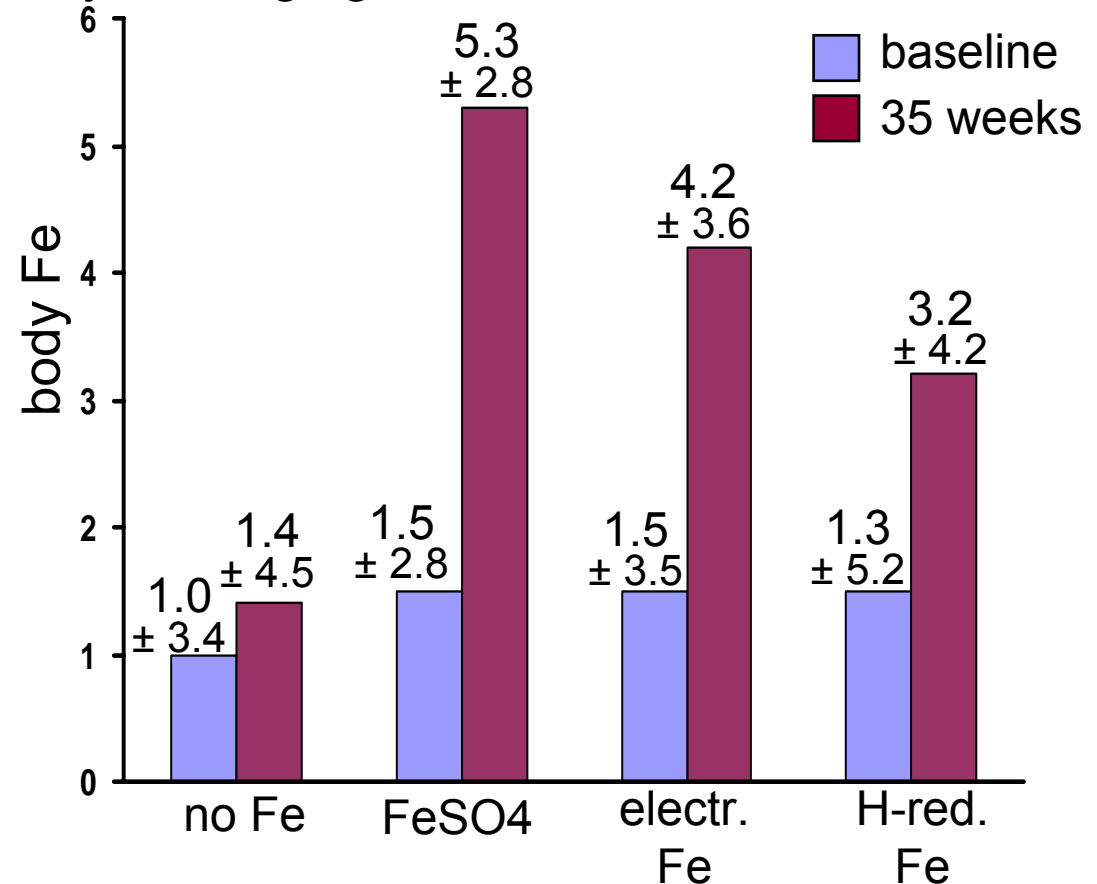
Electrolytic iron and H-reduced iron are efficacious iron fortificants for white wheat flour (Zimmermann et al 2005)

- ★ randomized, double blind, controlled trial in 330 women of CBA with SF <math><25\mu\text{g/L}</math>
- ★ fed 6d/wk, 35 wks, wheat flour snack with 12mg Fe as: ferrous sulphate, electrolytic Fe, H-reduced Fe, no iron
- ★ monitored body Fe stores with SF and TfR
- ★ relative efficacy

electrolytic Fe	79%
H-reduced Fe	49%

(p < 0.01)

body iron mg/kg BW at baseline and 35 wks



Many countries appear not to follow the CDC Guidelines on flour fortification

- ◆ South Africa (van Stuivenberg et al)
 - add 35 ppm as electrolytic iron
recommendation is 60-90 ppm
now experimenting with NaFeEDTA/fumarate

- ◆ Oman (Suleiman et al)
 - 30 ppm as elemental iron, ca 30g/d consumption
after 8y still >30% women with ID and 20% with IDA
CDC recommends 90 ppm as electrolytic iron, 60ppm as FS