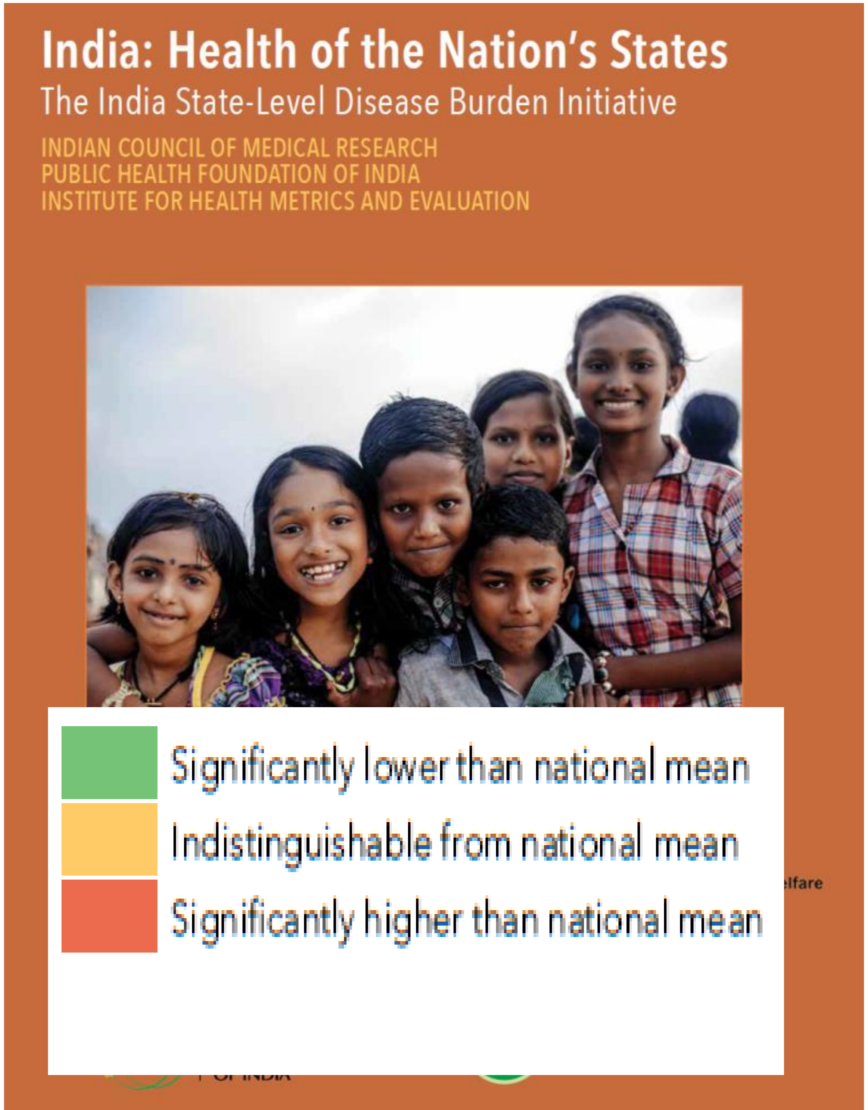
# Interventions to improve iron status with food fortification and dietary diversification

K. Madhavan Nair PhD, FNAMS, FNAAS, FTAS
Scientist-F (Retd.)
National Institute of Nutrition (ICMR),
Vice President, Nutrition Society of India
nairthayil@gmail.com

29-11-2017
Kamala Raheja Auditorium, JJ Bajaj Centre for Multi-Professional Education, NAMS House, Ansari Nagar, New Delhi

# DALYs rate of IDA in the states of India




Significantly lower than national mean

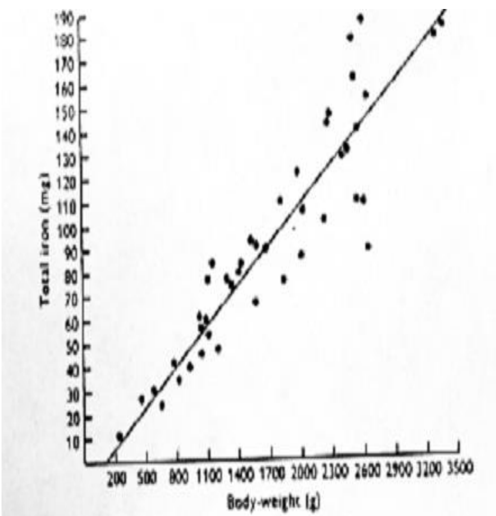
Indistinguishable from national mean

Significantly higher than national mean

| | |
|---|---|
| India | 1235 |
| EAG States | 1376 |
| Lowest ETL group | 1376 |
| Bihar | 1610 |
| Chhattisgarh | 1196 |
| Jharkhand | 1471 |
| Madhya Pradesh | 1335 |
| Odisha | 1246 |
| Rajasthan | 1397 |
| Uttar Pradesh | 1319 |
| Lower-middle ETL group | 1008 |
| Uttarakhand | 1008 |
| North-East states | 1282 |
| Lowest ETL group | 1451 |
| Meghalaya | 1218 |
| Assam | 1472 |
| Lower-middle ETL group | 820 |
| Arunachal Pradesh | 887 |
| Mizoram | 678 |
| Nagaland | 537 |
| Tripura | 1197 |
| Sikkim | 954 |
| Manipur | 463 |
| Other states | 1104 |
| Lower-middle ETL group | 1228 |
| Gujarat | 1228 |
| Higher-middle ETL group | 1114 |
| Haryana | 1293 |
| Delhi | 925 |
| Telangana | 1055 |
| Andhra Pradesh | 1294 |
| Jammu and Kashmir | 953 |
| Karnataka | 1106 |
| West Bengal | 1157 |
| Maharashtra | 1077 |
| Union Territories other th | 990 |
| Highest ETL group | 987 |
| Himachal Pradesh | 813 |
| Punjab | 1093 |
| Goa | 645 |
| Tamil Nadu | 1199 |
| Kerala | 515 |

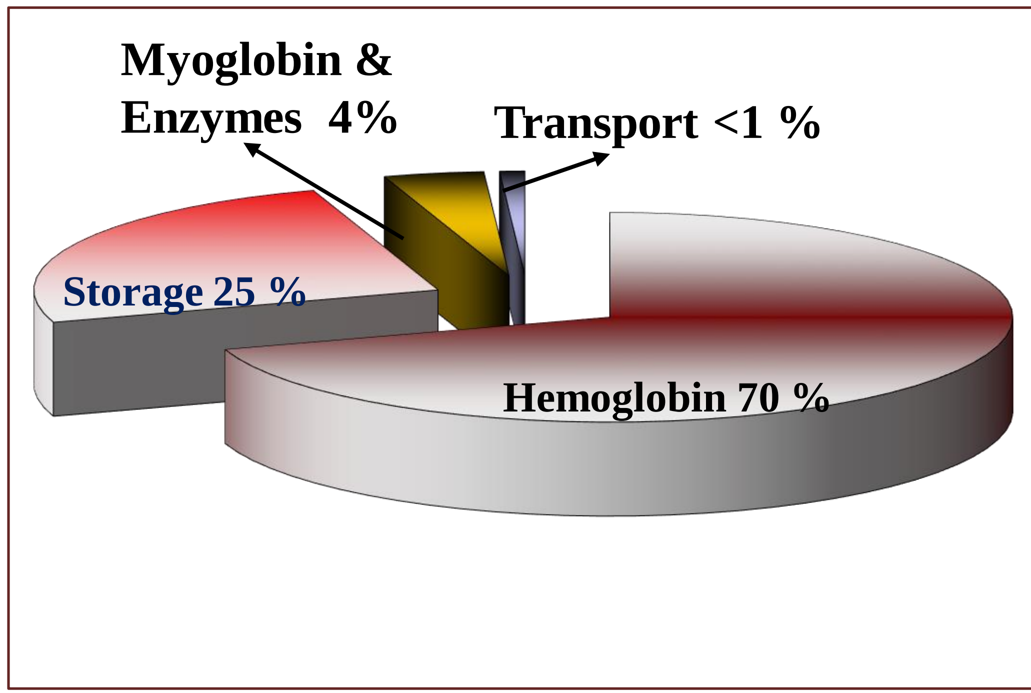
# The foundation of adequate iron status is laid before birth, during childhood, and is followed during adolescence

Relationship between total iron and weight of fetus



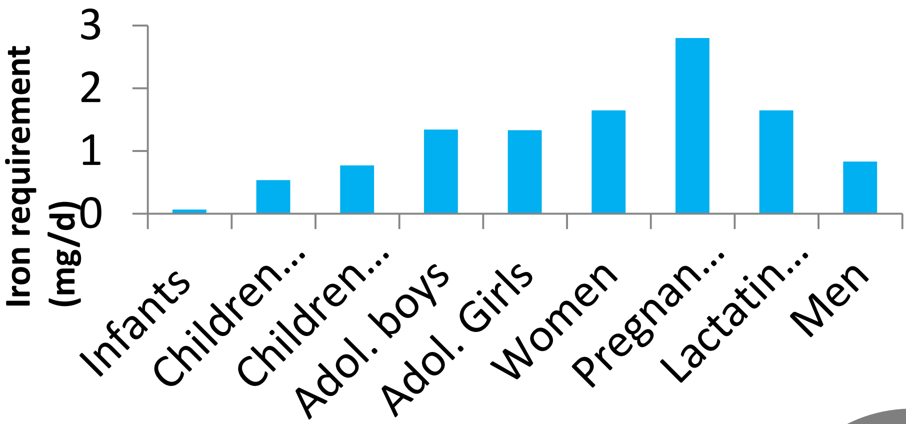
Apte and Iyengar, Br. J.Nutr. 1972, 27: 305 - 12

Building up of iron store is very essential for iron balance

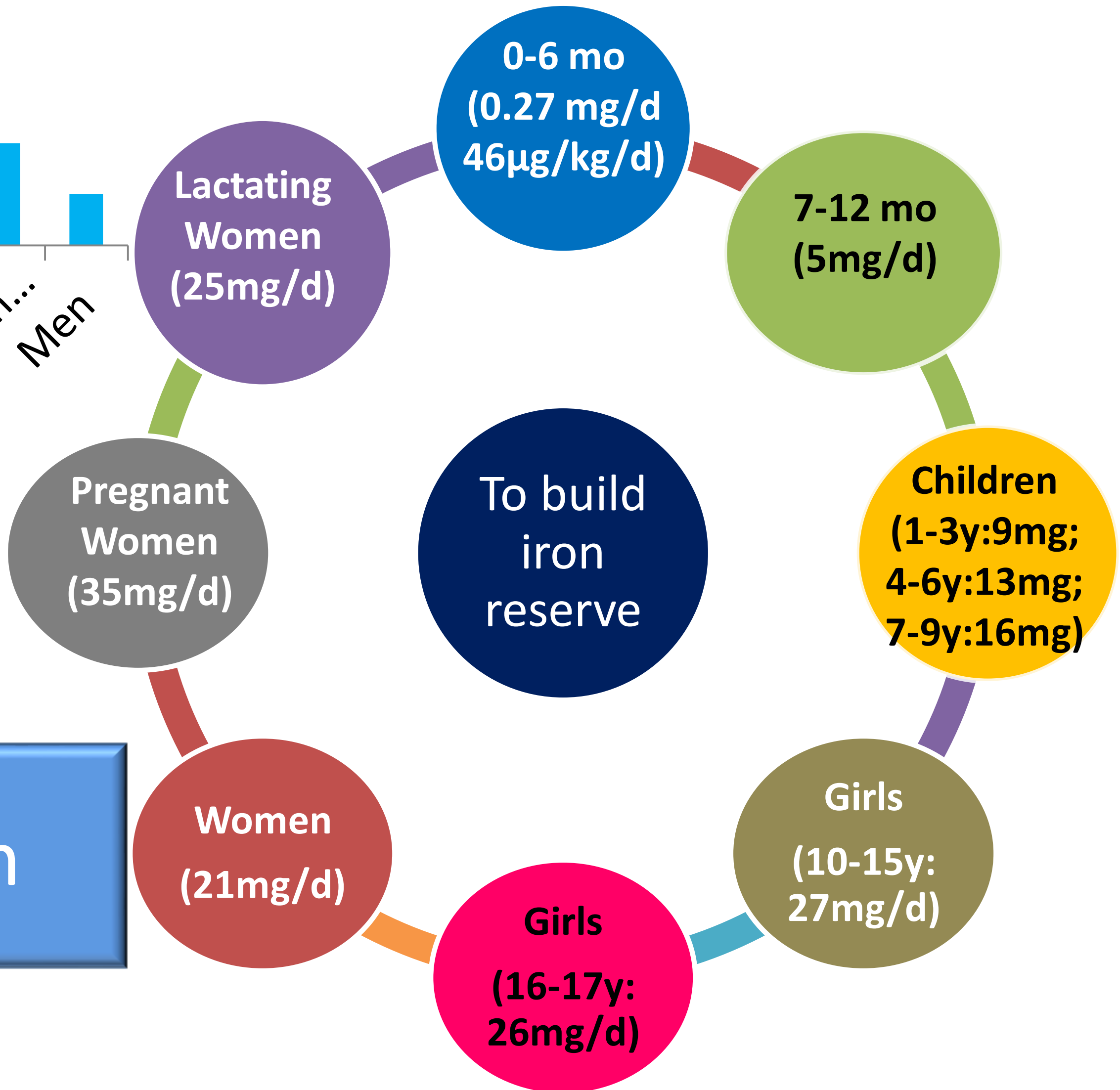



**Iron stores absent or insufficient throughout life cycle**

# Meeting iron requirement is a prerequisite for preventing iron deficiency throughout the life cycle

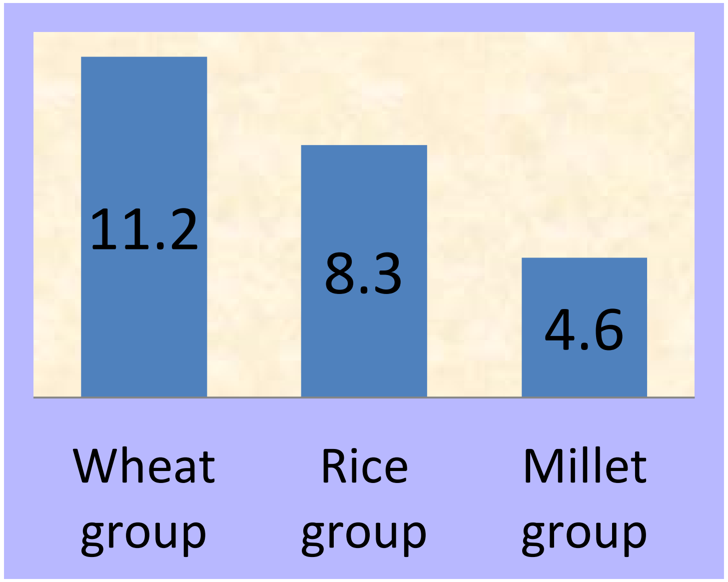



Habitual diet: low iron

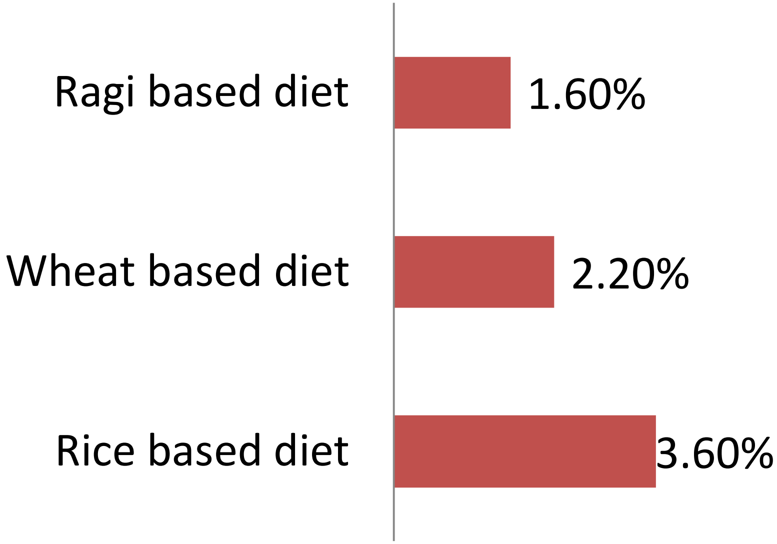


# Host and dietary factors determine iron bioavailability

## Iron deficient women



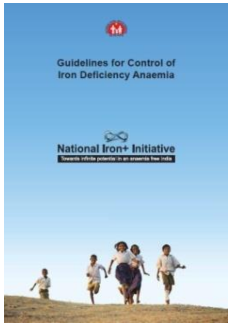

## adult males




Food synergy to improve iron bioavailability

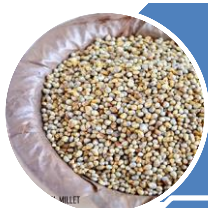
Kalasuramath *et al* *IJMR* 2013; 137:324-330 Rao and Prabhavathi *AJCN* 1978; 31: 169- 175

# CURRENT STRATEGIES TO MEET RDA OF IRON




National Iron +

Fortified staple foods



Bio Fortified staple foods

Dietary diversification


Health Care facility & WASH

# Food fortification

**Addition of one or more essential nutrients to a food for the purpose of preventing or correcting a demonstrated deficiency in the population or specific population groups.**

**Vehicles for Iron fortification**

**Wheat flour/Rice/Maize/salt**

**Regional strategies**

**Fish Sauce/Curry Powder**

# Food fortification has a successful track record in many countries

**Long history of safe use in many countries for successful control of deficiencies of vitamins A, D, several B vitamins, iodine and iron**

- **Ranked as the best global welfare investment**

# Food Fortification Works

For more than 80 years, wheat flour has been fortified with iron and other nutrients in developed countries

**Mandatory:** In October 2017, 87 countries have legislation to fortify wheat flour, maize flour, and/or rice.

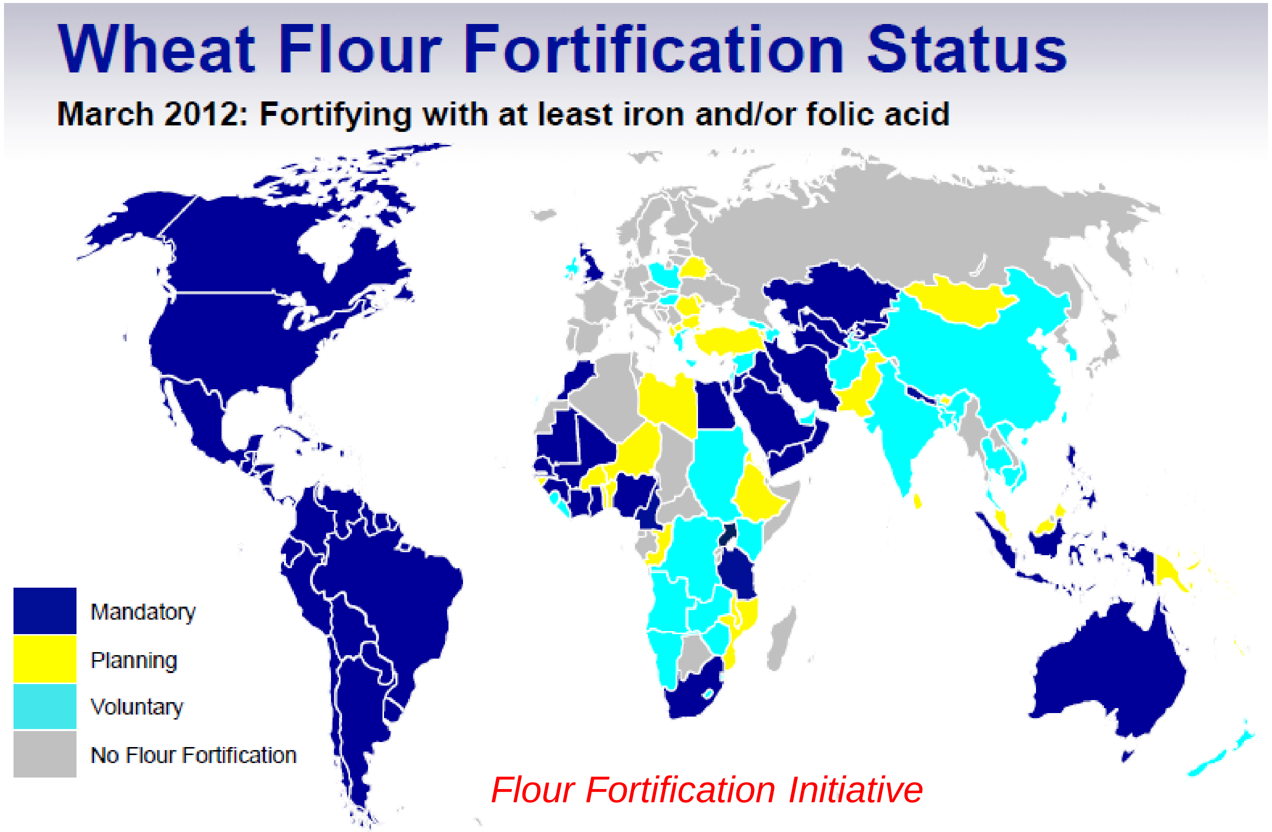


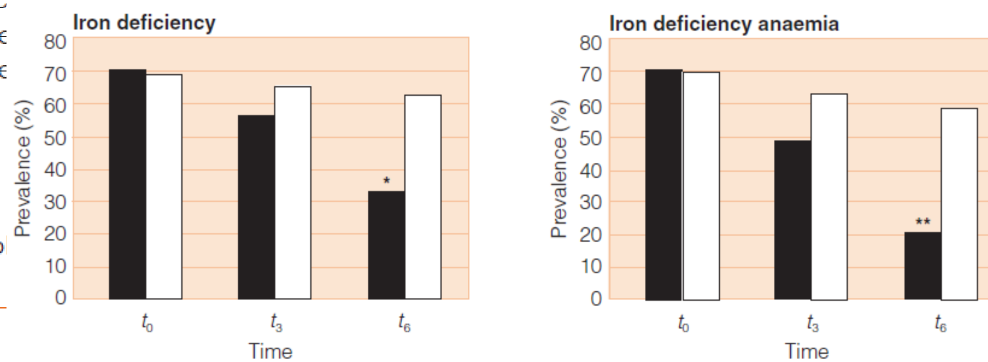
TABLE 5.2

**Suggested iron fortificants for specific food vehicles**

| Food vehicle | Fortificant |
|---|---|
| Low extraction (white) wheat flour or degermed corn flour | Dry ferrous sulfate |
| | Ferrous fumarate |
| | Electrolytic iron (×2 amount) |
| | Encapsulated ferrous sulfate |
| | Encapsulated ferrous fumarate |
| High extraction wheat flour, corn flour, corn masa flour | Sodium iron EDTA |
| | Ferrous fumarate (×2 amount) |
| | Encapsulated ferrous sulfate (×2 amount) |
| | Encapsulated ferrous fumarate (×2 amount) |
| Pasta | Dry ferrous sulfate |
| Rice[a] | Ferric pyrophosphate (×2 amount) |
| Dry milk | Ferrous sulfate plus ascorbic acid |
| Fluid milk | Ferric ammonium citrate |
| | Ferrous bisglycinate |
| | Micronized ferric pyrophosphate |
| Cocoa products | Ferrous fumarate plus ascorbic acid |
| | Ferric pyrophosphate (×2 amount) plus ascorbic acid |
| Salt[a] | Encapsulated ferrous sulfate |
| | Ferric pyrophosphate (×2 amount) |
| Sugar[a] | Sodium iron EDTA |
| Soy sauce, fish sauce | Sodium iron EDTA |
| | Ferrous sulfate plus citric acid |
| Juice, soft drinks | Ferrous bisglycinate, ferrous lac |
| | Micronized ferric pyrophosphate |
| Bouillon cubes[a] | Micronized ferric pyrophosphate |
| Cereal-based complementary foods[b] | Ferrous sulfate |
| | Encapsulated ferrous sulfate |
| | Ferrous fumarate |
| | Electrolytic iron (×2 amount) |
| | All with ascorbic acid (≥2 : 1 mo |
| Breakfast cereals | Electrolytic iron (×2 amount) |

FIGURE 1.1

**Effect of iron fortification of fish sauce on iron status of non-pregnant anaemic female Vietnamese factory workers**




*Prevalence of iron deficiency and iron deficiency anaemia at baseline, and after 3 and 6 months of intervention in the iron intervention group ■ (10 mg iron/day in NaFeEDTA-fortified fish sauce (n = 64)) and the control group □ (n = 72) in anaemic Vietnamese women.*

# Guidelines on food fortification with micronutrients

Edited by Lindsay Allen, Bruno de Benoist, Omar Dary and Richard Hurrell

World Health Organization

Food and Agricultural Organization of the United Nations

- Focus on wheat flour fortification
- Key micronutrients –iron, folic acid, zinc , vitamin B12 and vitamin A, D
- Fortification levels and technical aspects
- General recommendations that needs to be adopted to local context- specific micronutrient intake and consumption level of food vehicle among different groups.

# Evidence of the effectiveness of flour fortification for reducing the prevalence of anemia is limited

**Countries included**:
Azerbaijan, Brazil, China, Fiji, India, Iran, Kazakhstan, Mongolia, Nepal, Sri Lanka, Tajikistan, Uzbekistan, and Venezuela

**Most reported fortification with iron**:
Wheat flour (n=10), wheat, maize flour (n=2), wheat, maize, millet flour (n=1)

**Population represented:**
Children ≤ 15 and women of reproduction age

| Biological marker | Children ≤15 y (n = 14 subgroups) | | | Women of reproductive age (n = 12 subgroups) | | |
|---|---|---|---|---|---|---|
| | Yes | No | Not assessed[a] | Yes | No | Not assessed[a] |
| Increased ferritin[b] | 3 | 3 | 8 | 5 | 0 | 7 |
| Decreased prevalence of low ferritin | 1 | 5 | 8 | 3 | 0 | 9 |
| Increased hemoglobin | 5 | 7 | 2 | 6 | 5 | 1 |
| Decreased prevalence of anemia | 4 | 9 | 1 | 4 | 8 | 0 |
| Decreased prevalence of IDA | 0 | 0 | 14 | 0 | 2 | 10 |

**Programs followed WHO iron recommendations for flour fortification or not ????**

Pachon et al *Nutr Rev 2015;1-16.* doi: 10.1093/nutrit/nuv037

Supplemental Material can be found at:
http://jn.nutrition.org/content/suppl/2017/06/07/jn.116.245076.DCSupplemental.html

The Journal of Nutrition
Community and International Nutrition

# Iron, Zinc, Folate, and Vitamin B-12 Status Increased among Women and Children in Yaoundé and Douala, Cameroon, 1 Year after Introducing Fortified Wheat Flour

Reina Engle-Stone,[1] Martin Nankap,[2] Alex O Ndjebayi,[2] Lindsay H Allen,[1,3] Setareh Shahab-Ferdows,[1,3] Daniela Hampel,[1,3] David W Killilea,[4] Marie-Madeleine Gimou,[5] Lisa A Houghton,[6] Avital Friedman,[2] Ann Tarini,[2] Rosemary A Stamm,[6] and Kenneth H Brown[1,7]

- Wheat flour fortification –fortified @ 45 mg Fe/kg, 71.25 mg Zn, 3.75 mg folic acid, and 0.03 mg vitamin B-12.

- Design: 2009 and 2012 in 30 clusters with target samples from 10 HHs -15-40 y women (n=300, wheat flour 96 g/d) and 10 1-5 y children (n=330, 77g/d).

# India: Double Fortified Salt (Iron + Iodine)

## EFFICACY TRIALS

### Double blind RCTs-2 (1990-02 & 1996-1998)

| Ingredients | Quantity |
|---|---|
| Common Salt (g) | 1000 |
| $FeSO_4\ 7H_2O$ (g) | 5 (Fe 1 mg/g) |
| $KI/KIO_3$ (mg) | 52 (40 µg/g) |
| SHMP (g) | 10 (10 mg/g) |

Nair KM et al. Indian J Med Res , 108: 203-211.1998;
Sivakumar et al Brit. J. Nutr.85: S167-S173. 2001;
Sivakumar et al Indian J Pediatrics 69: 617-623, 2002


# Efficacy of iron and other micronutrient fortification

Triple fortification: Micro-encapsulated iodine, iron and vitaminA

Zimmermann etal Am J Clin Nutr 80:1283-90, 2004.

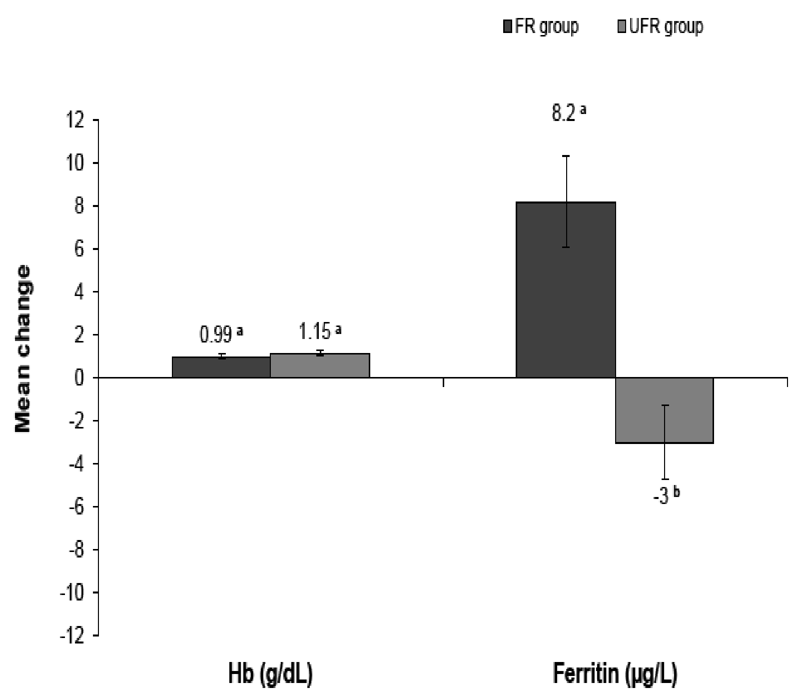
Multiple micronutreint: Fe, I, Ca, Vitamins A, B1, B2, B12, B6, Folic acid,

Vinodkumar & Rajagopalan, Eur. J Clin Nutr, 63:437-445, 2009Sundar Serendipity Foundation, Chennai

# Micronized ferric pyrophosphate supplied through extruded rice kernels improves body iron stores in children: a double-blind, randomized, placebo-controlled midday meal feeding trial in Indian schoolchildren[1–3]

*The American Journal of Clinical Nutrition* 2011;94:1202–10.

*Madhari S Radhika, Krishnapillai M Nair, Rachakulla Hari Kumar, Mendu Vishnuvardhana Rao, Punjal Ravinder, Chitty Gal Reddy, and Ginnela NV Brahmam*




Introduced in 2 states as part of Mid-day meal programme

# Iron fortified rice

| Design MDM | Duration | Source of iron and dose | Impact | | |
|---|---|---|---|---|---|
| | | | Change in prevalence | Hemoglobin g/dl | Ferritin μg/L |
| RCT, Bangalore School lunch Iron depleted children N= 184 | 7 months Dewormed at Baseline and at 3.5 months | Extruded rice fortified with Micronized ferric pyrophosphate / 20 mg | Control | -0.6 | +2.3 |
| | | | Fortified | - 0.2 | +9.5 |

Moretti et al Am J Clin Nutr 84:822-29, 2006

*What works? Interventions for maternal and child undernutrition and survival*

Bhutta et al; Lancet 2008, DOI:10.1016/S0140-6736(07)61693-6

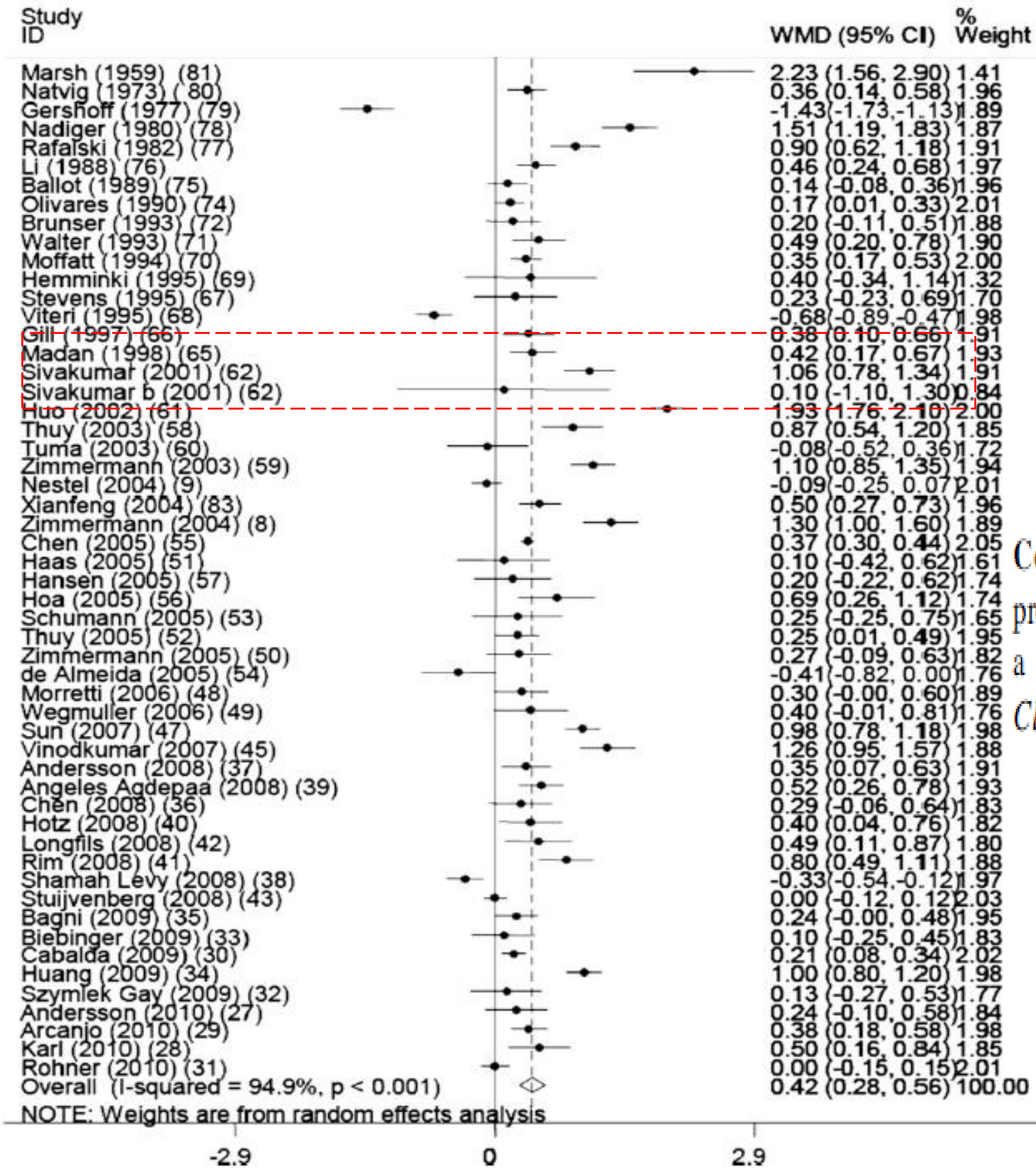
# Food fortification

| | Prenatal and antenatal* | Neonates (0–1 month)† | Infants (1–12 months) | Children (12–59 months) |
|---|---|---|---|---|
| Food fortification strategies and programmes (including iodised salt, iodisation of water, and fortification with iron and vitamin A) | Improved micronutrient status (haemoglobin concentration weighted mean difference in women of child bearing age 5·70 g/L, 95% CI 0·02–11·38). In pregnant women, 6·90 g/L higher compared with no fortification (WMD 6·90, 2·74–11·06). Programmes for universal iodisation of salt decreased goitre prevalence by 19–64%. Rate of goitre reduced by 51–89% by iodisation of water | Neonatal mortality reduced by 65·7% after iodisation of water | Improved micronutrient status (haemoglobin concentration WMD 7·36 g/L, 2·88–11·84). Infant mortality decreased 56·5% after iodisation of water | Improved micronutrient status (haemoglobin WMD 7·36 g/L, 2·88–11·84). After 24 months of age, use of fortified foods including milk has improved micronutrient status (WMD 10·33 from a meta-analysis of studies). Additional reduction in diarrhoea morbidity noted in one study. Fortified milk reduced odds for days with severe illnesses by 15% (5–24%), the incidence of diarrhoea by 18% (7–27%), and the incidence of acute lower respiratory illness by 26% (3–43%) |

**Hb: Weighted mean difference in women =5.7 g/L**
**Pregnant women =6.9 g/L**
**Infants and children=7.36g/L**

# Effect of iron-fortified foods on hematologic and biological outcomes: systematic review of randomized controlled trials[1–4] *Am J Clin Nutr* 2012;96:309–24.

*Tarun Gera, Harshpal Singh Sachdev, and Erick Boy*




**Conclusion:** Consumption of iron-fortified foods results in an improvement in hemoglobin, serum ferritin, and iron nutriture and a reduced risk of remaining anemic and iron deficient. *Am J Clin Nutr* 2012;96:309–24.

Public Health Nutrition: 17(3), 579–586 doi:10.1017/S1368980013000062

## Review Article

# Impact of iron-fortified foods on Hb concentration in children (<10 years): a systematic review and meta-analysis of randomized controlled trials

Ramesh Athe[1], M Vishnu Vardhana Rao[1,]* and K Madhavan Nair[2]
[1]Division of Biostatistics, National Institute of Nutrition, Indian Council of Medical Research, Jamai-Osmania, Hyderabad – 500007, Andra Pradesh, India: [2]Division of Micronutrient Research, National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India



| Study or subgroup | Intervention Mean | Intervention SD | Intervention *n* | Control Mean | Control SD | Control *n* | Weight (%) | Mean difference IV, random (95 % CI) |
|---|---|---|---|---|---|---|---|---|
| Osei (2010) | 123·2 | 14·8 | 220 | 122·5 | 15.3 | 235 | 4·4 | 0·70 (–2·07, 3·47) |
| de Almeida (2003) | 116·0 | 10·9 | 50 | 104·8 | 16.6 | 50 | 3·4 | 11·20 (5·70, 16·70) |
| Bradley (1993)_1 | 122 | 11 | 34 | 118 | 12 | 41 | 3·5 | 4·00 (–1·21, 9·21) |
| Bradley (1993)_2 | 119 | 10 | 20 | 115 | 8 | 21 | 3·4 | 4·00 (–1·56, 9·56) |
| Bradley (1993)_3 | 122 | 11 | 28 | 120 | 10 | 41 | 3·6 | 2·00 (–3·10, 7·10) |
| Bradley (1993)_4 | 117 | 11 | 21 | 113 | 7 | 26 | 3·4 | 4·00 (–1·42, 9·42) |
| Moretti (2006)_1 | 123 | 10 | 92 | 112 | 12 | 92 | 4·3 | 11·00 (7·81, 14·19) |
| Moretti (2006)_2 | 119 | 9 | 92 | 116 | 11 | 92 | 4·4 | 3·00 (0·10, 5·90) |
| de Oliveira (1996) | 117 | 11 | 44 | 109 | 12 | 44 | 3·7 | 8·00 (3·19, 12·81) |
| Giorgini (2001) | 126 | 13 | 89 | 115 | 11·1 | 89 | 4·1 | 11·00 (7·45, 14·55) |
| Rim (2008) | 118·0 | 11·7 | 107 | 110·0 | 11·1 | 104 | 4·3 | 8·00 (4·92, 11·08) |
| Le Huong (2007) | 125·4 | 14·5 | 72 | 123·4 | 15·0 | 73 | 3·7 | 2·00 (–2·80, 6·80) |
| Varma (2007)_1 | 116·9 | 10·3 | 244 | 109·9 | 10·3 | 269 | 4·7 | 7·00 (5·22, 8·78) |
| Varma (2007)_2 | 128 | 11 | 244 | 124 | 14 | 269 | 4·6 | 4·00 (1·83, 6·17) |
| Beinner (2005) | 124 | 9 | 160 | 118 | 13 | 160 | 4·5 | 6·00 (3·55, 8·45) |
| van Stuijvenberg (2006) | 127·1 | 7·5 | 53 | 127·5 | 7·4 | 51 | 4·4 | –0·40 (–3·26, 2·46) |
| Sari (2001) | 120·8 | 7·8 | 57 | 115·3 | 7·9 | 60 | 4·4 | 5·50 (2·65, 8·35) |
| Andang'o (2007) | 112·2 | 9·9 | 127 | 115·7 | 9·7 | 128 | 4·5 | –3·50 (–5·91, –1·09) |
| Moreira-Araújo (2007) | 131 | 10 | 130 | 118 | 12 | 130 | 4·4 | 13·00 (10·31, 15·69) |
| Sazawal (2010) | 109·0 | 11·4 | 233 | 95·4 | 15·4 | 232 | 4·5 | 13·60 (11·14, 16·06) |
| Nga (2009)_1 | 121·2 | 7·3 | 114 | 120·1 | 8·0 | 118 | 4·6 | 1·10 (–0·87, 3·07) |
| Nga (2009)_2 | 122·2 | 6·2 | 118 | 120·1 | 8·0 | 118 | 4·7 | 2·10 (0·27, 3·93) |
| van Stuijvenberg (2001) | 129·1 | 8·1 | 108 | 125·5 | 8·1 | 108 | 4·6 | 3·60 (1·44, 5·76) |
| Zimmermann (2006) | 121 | 9 | 66 | 119 | 12 | 68 | 4·1 | 2·00 (–1·58, 5·58) |
| Total (95 % CI) | | | 2523 | | | 2619 | 100·0 % | 5·09 (3·23, 6·95) |

Heterogeneity: $\tau^2 = 18{\cdot}37$; $\chi^2 = 226{\cdot}03$, df = 23 ($P < 0{\cdot}00001$); $I^2 = 90\,\%$
Test for overall effect: $Z = 5{\cdot}38$ ($P < 0{\cdot}00001$)

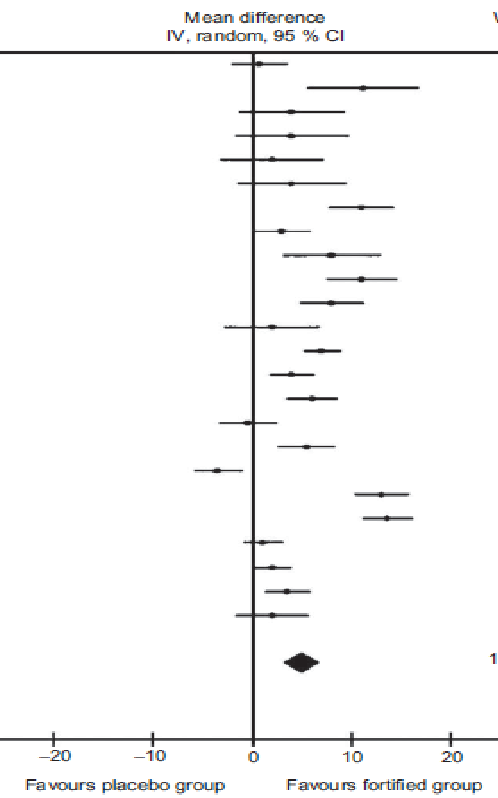



**Fig. 2** Forest plot: effect of iron fortification on mean difference in Hb concentration in comparison with no intervention or placebo control in children (<10 years). Random-effects meta-analysis of weighted mean difference (WMD; and 95 % CI) on Hb concentration with iron-fortified food intervention compared with control group. The sizes of data markers indicate the weight of each study in the analysis. Horizontal lines represent 95 % CI. Blob indicates best estimate and diamond indicates the summary estimate of the WMD

fssai

FOOD SAFETY AND STANDARDS AUTHORITY OF INDIA

*Inspiring Trust, Assuring Safe & Nutritious Food*

## DIFFERENT IRON SOURCES

SALT
ATTA
MAIDA
RICE
PROCESSED FOODS

**FOOD SAFETY AND STANDARDS**
**(FORTIFICATION OF FOODS)**
**REGULATION 2016**

+F FORTIFIED
SAMPOORNA POSHAN SWASTH JEEVAN

+F फोर्टिफाइड
सम्पूर्ण पोषण स्वस्थ जीवन

| S.No. | Nutrient | Minimum Level of Fortification per Kg |
|---|---|---|
| 1. | Iron- Sodium Iron (III) Ethylene diamine tetra Acetate, Trihydrate (Sodium federate-Na Fe EDTA); | 20 mg |
| 2. | Folic acid | 1300 μg |
| 3. | VitaminB12-cyanocobalamine, hydroxycobalamine; | 10 μg |

# Ascorbic acid chelates in iron absorption: a role for HCl and bile

**The chemical reaction of $FeCl_3$ and ascorbic acid must be initiated at an acid pH to ensure solubility of iron at pH of the duodenum**

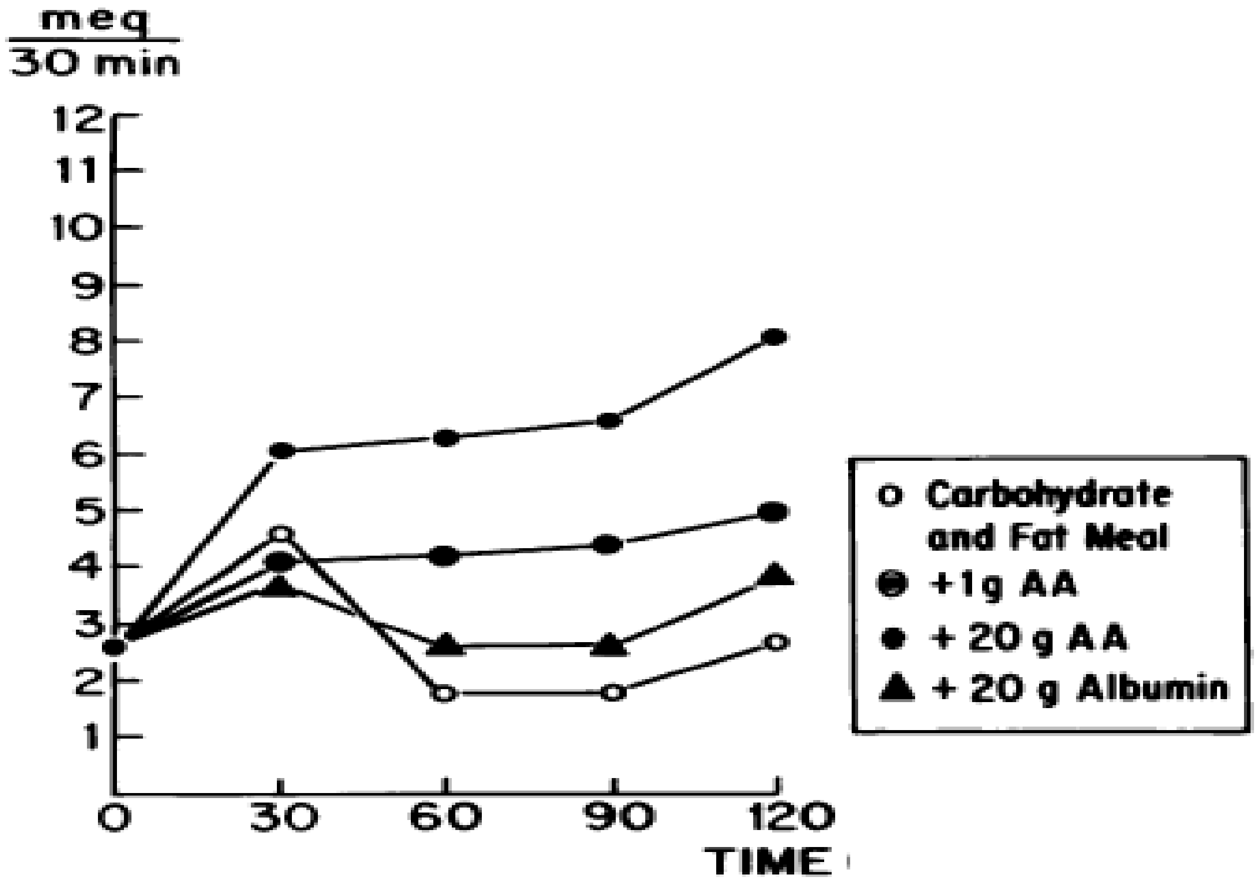
**($FeCl_3$+ascorbic acid) + base $\longrightarrow$ soluble iron chelate**

**($FeCl_3$+base ) + ascorbic acid $\longrightarrow$ insoluble iron precipitate.**

Conrad ME. & Schade SG.. Gastroenterology 55: 35–45, 1968.

# Bioavailability of dietary iron depends

**Food stimulated gastric acid secretion**

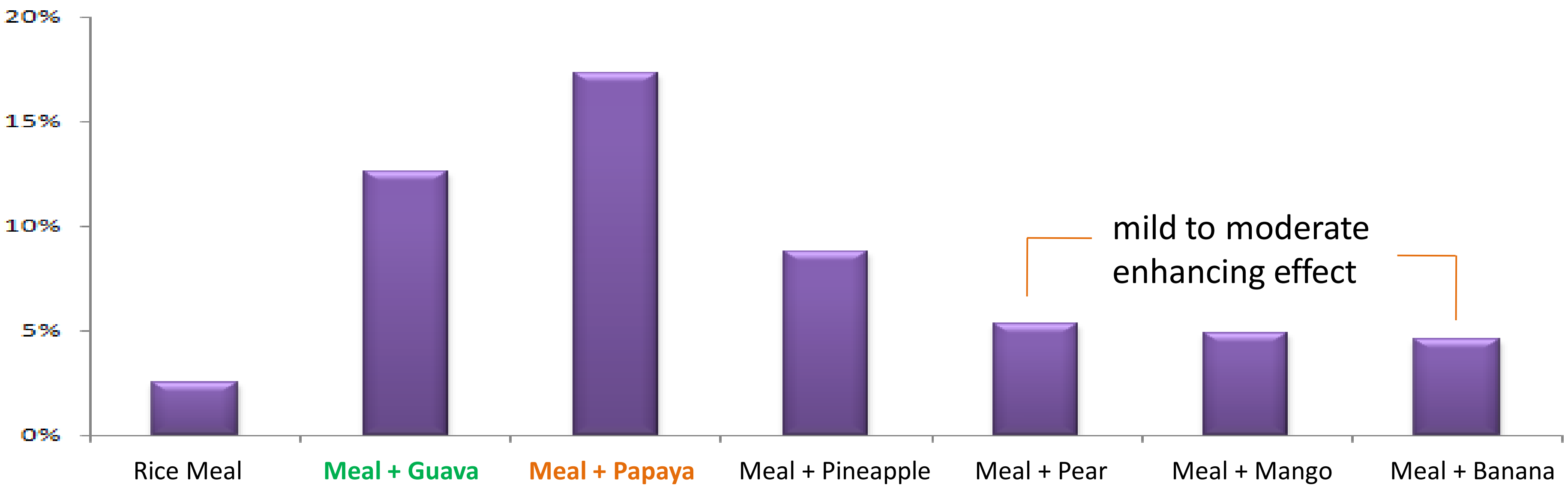



The Journal of Clinical Investigation Volume 58 September 1976·623–631

# Effect of Different Fruits on Iron Absorption :

Absorption of iron from a rice meal
22–74y aged Durban-Indian women (N= 234)

Close correlation between Fe absorption and the ascorbic acid content of the fruits *(r = 0.738, P < 0.0001).*

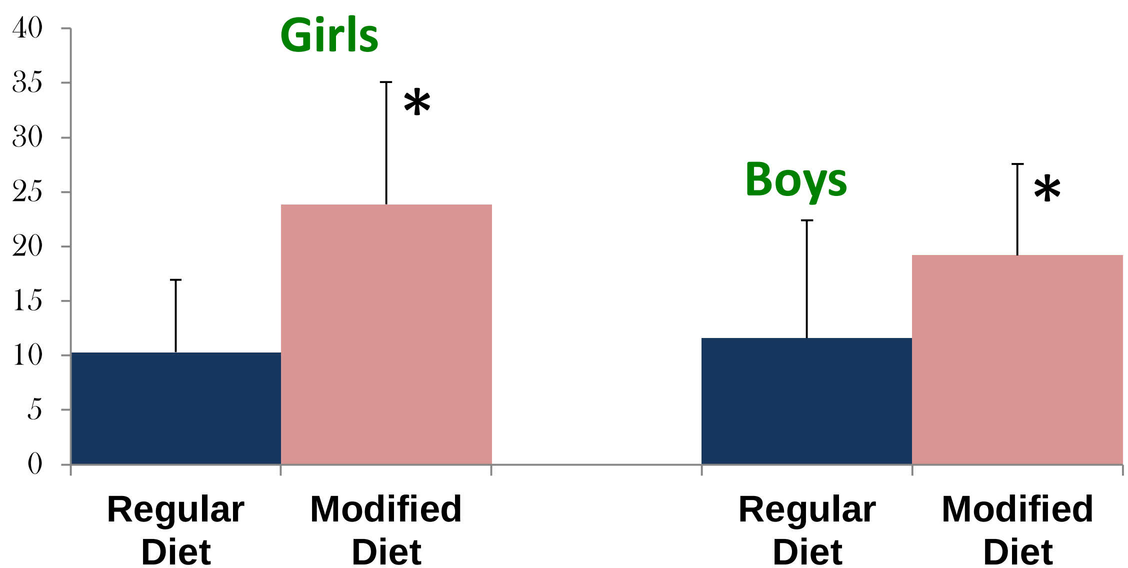



*Ballot et.al 1987. British Journal of Nutrition, 51: 331-343*

The Journal of Nutrition
**Nutrient Requirements and Optimal Nutrition**

# Inclusion of Guava Enhances Non-Heme Iron Bioavailability but Not Fractional Zinc Absorption from a Rice-Based Meal in Adolescents[1,2]

Krishnapillai Madhavan Nair,[3]* Ginnela N.V. Brahmam,[4] Madhari S. Radhika,[4] Roy Choudhury Dripta,[3] Punjal Ravinder,[3] Nagalla Balakrishna,[5] Zhensheng Chen,[6] Keli M. Hawthorne,[6] and Steven A. Abrams[6]




100 g Guava

# Haemoglobin repletion in anaemic adolescent girls

The intervention group received 100 g guava fruit with the lunch and dinner meals

Intervention Group: Baseline 10.7g/dLto end line 12.9g/dL

**1.9 g/dl**

Control group: Baseline 11.0 to end line 11.3 g/dL.

Seshadri S. Science for Health and Nutrition Security, A Feschrift for Dr.C.Gopalan, NFI, New Delhi , 229-35, 2008



# Food based approaches to increase iron bioavailability

- Guavas
- Ber
- Grapes black
- Grapes green
- Goras amli
- Mango ripe
- Pine apple
- Pomegranate
- Papaya
- Orange
- Sapota

# Micronutrient sachet

- Home or point of use/care fortification

- They provide easy-to use, practical solutions to mothers and caregivers who are interested in improving the vitamin and mineral health of their children.

- Acceptability high (Hanumante, 2008)

- Effective in reducing ID (Hanumante, 2008; Hirve, 2007.

Ann. N.Y. Acad. Sci. ISSN 0077-8923

ANNALS OF THE NEW YORK ACADEMY OF SCIENCES
Issue: *Integrating Nutrition and Early Childhood Development Interventions*

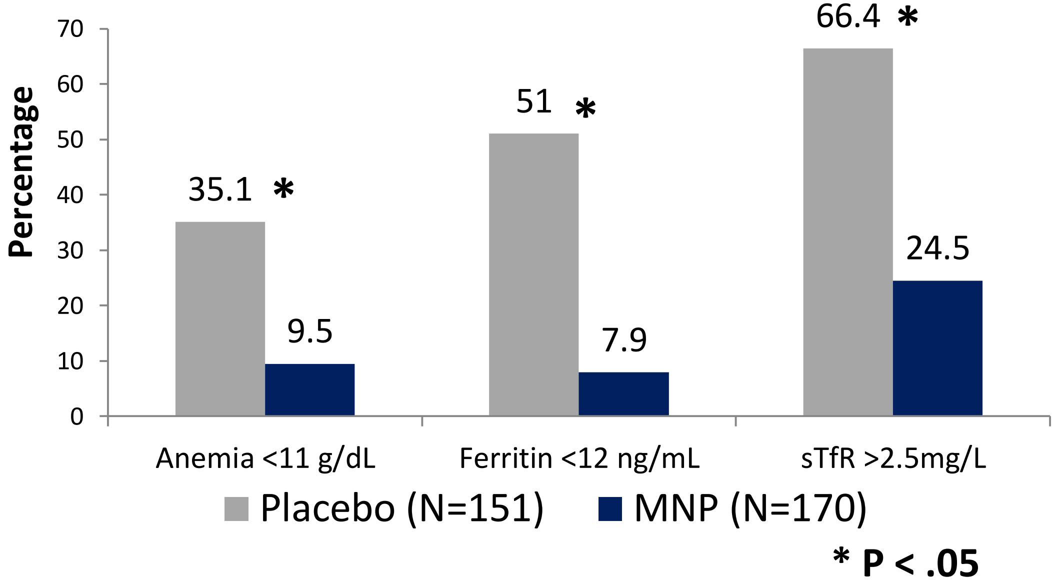
# Integrating nutrition and early child-development interventions among infants and preschoolers in rural India

Sylvia Fernandez-Rao,[1] Kristen M. Hurley,[2,3] Krishnapillai Madhavan Nair,[4] Nagalla Balakrishna,[5] Kankipati V. Radhakrishna,[6] Punjal Ravinder,[4] Nicholas Tilton,[4] Kimberly B. Harding,[7] Greg A. Reinhart,[8] and Maureen M. Black[2]

[1]Department of Behavioural Sciences, National Institute of Nutrition, Hyderabad, India. [2]Department of Pediatrics, University of Maryland School of Medicine, Baltimore, Maryland. [3]Department of International Health, The Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland. [4]Department of Micronutrient Research, National Institute of Nutrition, Hyderabad, India. [5]Department of Biostatistics, National Institute of Nutrition, Hyderabad, India. [6]National Institute of Nutrition, Hyderabad, India. [7]The Micronutrient Initiative, Ottawa, Canada. [8]The Mathile Institute for the Advancement of Human Nutrition, Dayton, Ohio


## Composition of product 'Grow-smart'

| | Grow Smart 3 (36+ months of age) | Placebo (all age groups) |
|---|---|---|
| Iron (encapsulated ferrous fumarate), mg | 13 | 0 |
| Vitamin A (retinyl palmitate), μg | 150 | 0 |
| Vitamin C (ascorbic acid), mg | 20 | 0 |
| Folic acid, μg | 20 | 0 |
| Zinc (zinc gluconate), mg | 5 | 0 |
| Vitamin $B_{12}$ (cobalamin), μg | 0.5 | 0 |
| Vitamin $B_2$ (riboflavin), mg | 0.5 | 0.5 |
| Maltodextrin | Filler | |




- ❑ Other micronutrients did not change significantly

# Biofortification

- Intervention strategy that makes the plants do the work of fortification
- Traditional plant breeding. **Selection and breeding** of high iron/ascorbic acid/low phytate varieties of major staple food crops with superior agronomic properties

**Table 3.** Number of households reached in target countries 2012–2015 (x 1000)

| Country–crop | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|
| Iron bean–Rwanda | 105 | 609 | 332 | 453 |
| Iron bean–DR Congo | 60 | 241 | 128 | 175 |
| Iron bean–Uganda | 29 | 69 | 43 | 39 |
| Iron pearl millet–India | 30 | 40 | 62 | 125 |
| Provitamin A maize–Zambia | 0 | 11 | 104 | 126 |
| Provitamin A cassava–Nigeria | 0 | 106 | 360 | 528 |
| Provitamin A cassava–DR Congo | 0 | 25 | 75 | 127 |
| Provitamin A orange sweet potato–Uganda | 33 | 76 | 107 | 132 |
| Zinc wheat–India | 0 | 1 | 6 | 36 |
| Zinc wheat–Pakistan | 0 | 0 | 0 | 3 |
| Zinc rice–Bangladesh | 0 | 1 | 18 | 160 |
| Total | 257 | 1179 | 1235 | 1865 |

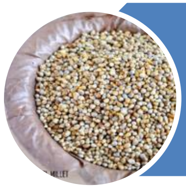
Ann. N.Y. Acad. Sci. 1390 (2017) 104–114 © 2017 New York Academy of Sciences

# Conclusions

National Iron +

Double fortified salt

Fortified wheat flour and rice



Bio Fortified staple foods

Dietary diversification strategies

Health Care facility & WASH

- Multiple channels of evidence based food fortification strategies are available
- Include fortified foods in the existing national programmes DFS, wheat flour and rice
- Popularize –Food synergy /simple dietary diversification to enhances iron  bioavailability
- Constantly monitor both functional benefits and biochemical effects


Thank You