# Can dietary strategies enhance zinc nutriture in low income countries?

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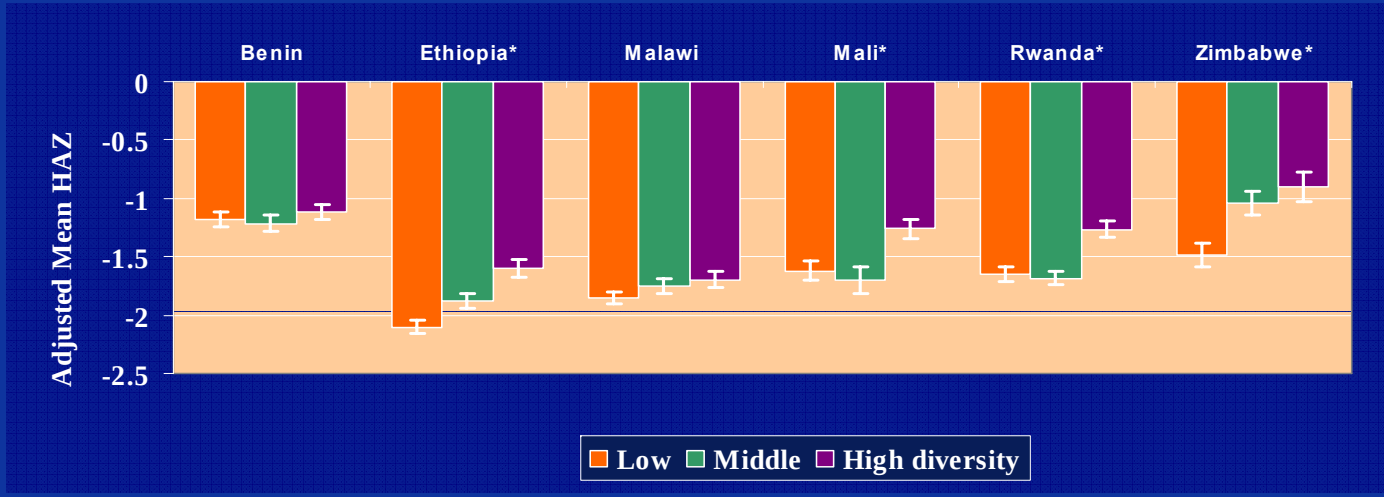
# What are the dietary strategies that can be used to prevent Zn deficiency?

1. Increase production & consumption of Zn-rich foods, especially cellular animal protein
2. Reduce phytate via household processing; i.e. soaking; germination; fermentation
3. Promote exclusive breastfeeding to 6 months
4. Promote safe & appropriate complementary foods at 6 months & continued breastfeeding to ≥ 2 y

See IZiNCG Technical Brief No. 5

# Why are DS important?: Adjusted mean HAZ by diet diversity tercile in six African countries (DHS data)




Means adjusted for child age, maternal height and BMI, # children < 5 y, and 2 wealth/welfare factor scores

Arimond & Ruel (2004)

# What are characteristics of diets inadequate in Zn?

- **Low content of bioavailable Zn***

  Based on unrefined, unfermented cereals & legumes with phytate-to-Zn molar ratios >18 (eg: Sub-Saharan Africa; rural diets in Latin America)

**OR**

- **Low content of Zn per se***

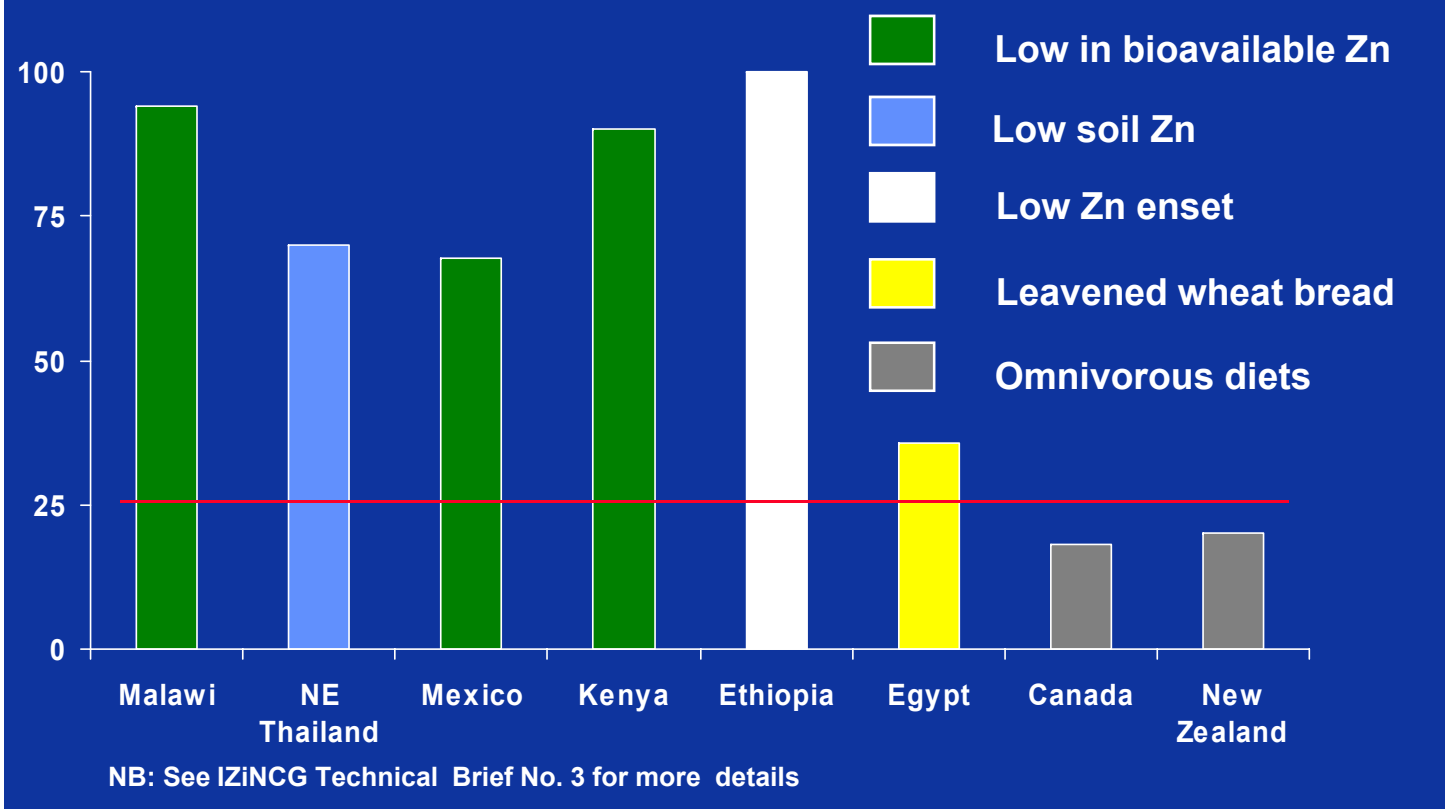
  Based on starchy roots & tubers low in Zn (e.g Sago in PNG; Enset in S.Ethiopia; Sweet Potatoes in Ecuador, Uganda)

  Or Based on a major staple grown on low-Zn soils (eg Rice in NE Thailand; Wheat: in Turkey, Iran, Pakistan)

  Or Based on *highly refined* cereals low in Zn (eg Refined Wheat Flour: complementary diets in Mongolia)

NB: Both diet types are low in cellular animal protein &, as a consequence, are low in heme iron, B-12, B-2, retinol, & fat

# Prevalence of inadequate intakes of Zn* in children and pregnant women (as %)




NB: See IZiNCG Technical Brief No. 3 for more details

# Zn, phytate (mg/100g) & phytate : Zn molar ratios in cereals, legumes, starchy roots,tubers vs beef & fish

| | | Zn | Phytate | Phy:Zn* |
|---|---|---|---|---|
| Cereals | Unrefined maize | 2.2 | 792 | 36 |
| | Refined maize | 0.9 | 211 | 23 |
| | Sorghum flour | 1.4 | 446 | 32 |
| | Brown rice, raw | 2.0 | 465 | 72 |
| | White rice, raw | 1.1 | 100 | 9 |
| Legumes | Kidney beans, dried | 1.5 | 460 | 72 |
| | Sesame seed: whole | 2.5 | 1525 | 61 |
| | Tofu | 0.7 | 290 | 45 |
| Starchy roots & tubers | Plantain | 0.2 | 0 | 0 |
| | Sago | 0.1 | 0 | 0 |
| | Enset | 0.1 | 7 | 8 |
| | Sweet Potato | 0.2 | 10 | 5 |
| Meat | Beef, lean | 6.3 | 0 | 0 |
| Fish | Usipa, dried w.bones | 25.4 | 0 | 0 |

## How can we improve diets in bioavailable Zn?

- **Increase intake of animal source foods (ASFs), especially meat, poultry, fish to increase zinc intakes**
- **Reduce phytate content of cereal-based diets to enhance Zn absorption by:**
  - soaking cereal & legume flours
    - » passive diffusion of water soluble phytate
  - using germinated cereals flours and/or fermentation
    - » hydrolysis of phytate by phytase enzymes

**Strategies also enhance intakes & bioavailability of other MNs:**

ASFs contribute B-12; B-2; heme Fe; retinol; Se; I; Ca; fat

Reducing phytate enhances bioavailability of Zn, Fe, & Ca

# Effect of consuming fish relish & removing phytate on nutrient content of maize-based Malawian diet

| | Zinc mg/d | Calcium mg/d | Phytate mg/d | Phy:Zn Molar ratio |
|---|---|---|---|---|
| Basal diet | 7.2 | 190 | 2168 | 30 |
| + dried whole fish relish | 12.1 | 444 | 1890 | 15 |
| + dried whole fish & soaked maize flour | 12.1 | 474 | 838 | 7 |
| RDA: Phy:Zn>18<br>Phy:Zn 5-18 | 9 mg<br>6 mg | 450<br>450 | | |

Basal diet: unrefined maize porridge; sweet potato; pumpkin leaf & pigeon-pea relish; groundnuts. Note: intakes of fat, Ca, B-12 also increased

,

## What is evidence that supply or promotion of ASFs can enhance Zn status & health outcomes of children?

- **ASFs in CFs (n=6; 5RCTs) or school snack (n=1 RCT):**
  - Sig. increase in Zn intakes (n = 4/5)
  - No increase in serum Zn (n=0/4); BUT ↑ in other MNs (e.g. Fe, B-12)
  - Sig. increase in growth (n=5/6); cognitive performance (n=1/1)
  - No reduction in morbidity (n=0/4)

**Conclusions:**

- Enriching CFs or school meals with ASFs can enhance zinc intakes, growth, & some aspects of development, irrespective of whether serum Zn increases
- Long-term sustainability & impact of promoting ASF intake unknown

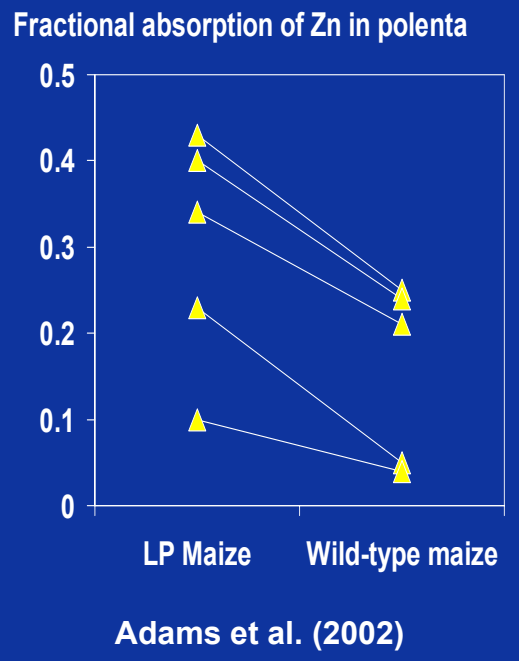
# What is the evidence that household phytate-reducing strategies can increase Zn absorption?

- Isotope studies (9/9): ↑ in Zn absorption w. ↓ in phytate
- No isotope studies using home processing

- Phytate loss in maize via home processing •~ 50% & similar to low phytate (LP) maize
- Significant increase in Zn absorption w. LP maize w. 60% loss (see Fig.)

**Conclusion: improved Zn absorption w. 50% phytate reduction via home processing likely**

**BUT intake of ASFs also needed to meet EAR for absorbed Zn for young children**




Adams et al. (2002)

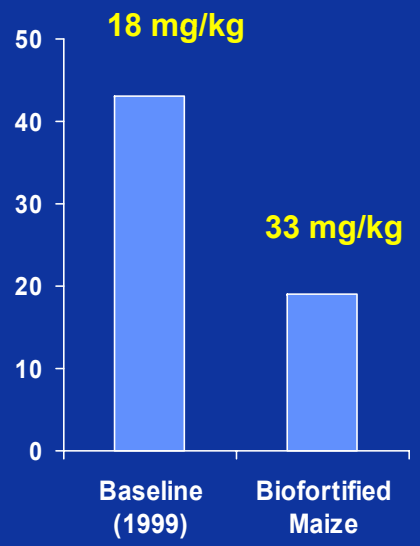
## How can we improve diets with low content of Zn?

- **Increase Zn content of staples via biofortification**
  - apply Zn fertilizer to low zinc soils to increase Zn content
  - use plant-breeding to increase Zn content : maize, rice, wheat
- **Increase Zn content of diets with animal source foods (ASFs)**
  - Beef, pork, lamb, liver: 6.8–3.0 mg/100g; Poultry 1.1–2.7 mg/100g;
  - Finfish: 0.3 –0.7 mg/100 g; Whole, dried Usipa: 25.4 mg/100g
  - Eggs: 1.3 mg/100g
  - ASF also increase fractional Zn absorption

**Impact on content of other micronutrients**

- ASFs may also contribute vit B-12; B-2; heme Fe; Ca; retinol, Se, I, fat, depending on the source

## Simulated impact of Zn biofortified maize on prevalence of inadequate intakes of Zn in Mexican children




## Effect of adding liver powder to daily diet of breast-fed infants in Mongolia 9-11 mos

| | Zn mg | Ca mg | Fe mg | B-2 mg | Vit A RE |
|---|---|---|---|---|---|
| Basal diet | 2.3 | 148 | 1.8 | 0.4 | 50 |
| + Liver powder | 3.9 | 150 | 3.8 | 1.5 | 410 |
| WHO Est. needs | 3.3* | 400 | 3.8 | 0.4 | 400 |

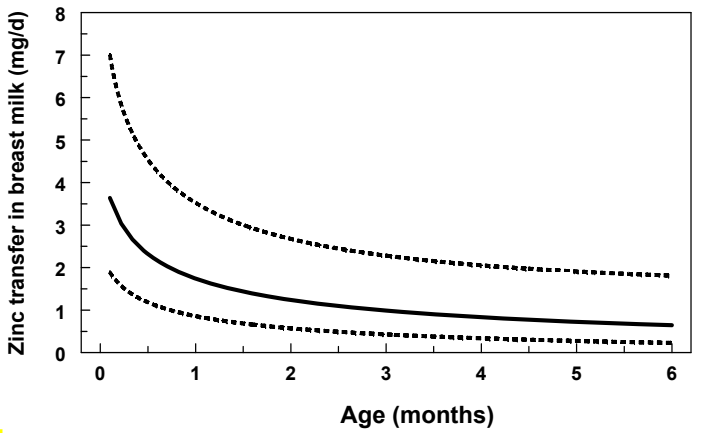
* Based on IZiNG RDA

# 3. What is evidence that Zn transfer in breast milk to BF infants < 6 mos meets absorbed Zn requirements?

- Curves show range of daily Zn intakes from BM by age

- Zn intake from BM is ~ 4 mg/d, then ~1.75 mg/d by 1 mo, & ~ 1.00 mg/d by 6 mo

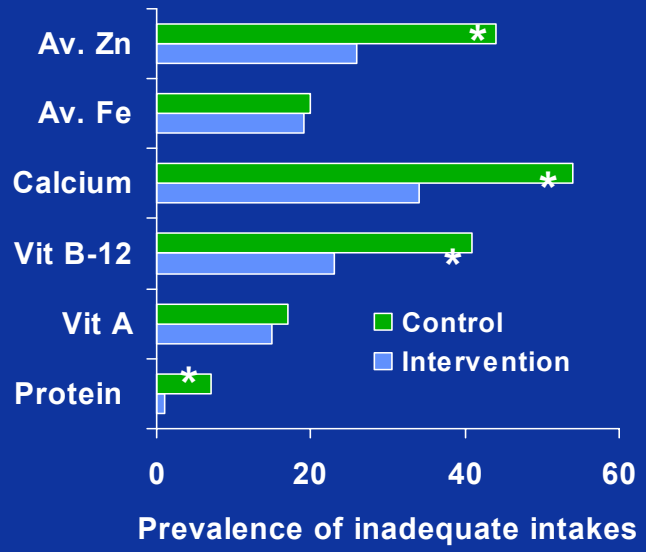
- BM Zn important source of bioavailable Zn: FAZ ~ 0.5 (n=2)




- BM Zn probably adequate for exclusively BF term infants until ~ 6 mos (n=3; RCTs)

Brown et al. (2009)

# Example: Efficacy of strategies to enhance content & bioavailability of Zn in diets of Malawian children




* P<0.05

## Impact on other outcomes

**Intervention vs. controls had:**

- More diverse diets of higher quality*
- Lower prevalence of anemia (62 vs. 80%)*
- Lower morbidity*
- Greater muscle mass*
- But: No effect on growth

From Yeudall et al. (2002, 2007)

# How can we enhance impact of dietary strategies?

- Use formative research to develop & test context-specific strategies
- Ensure behavior change communication is *effective*
- Optimize study design & time period to assess efficacy
- Include process & output indicators to monitor progress
  - to assess how well inputs & delivery system are functioning
  - to monitor intermediate effects and make adjustments, if needed
- Use outcome indicators to evaluate:
  - Exposure: via KAP; Prevalence of inadequate Zn intakes*
  - Impact: Serum zinc; Growth; Morbidity

KAP: knowledge, attitudes, practice  *See IZiNCG Technical Brief No. 3 for details

# What are implications of dietary strategies for programs?

- Promote & support breastfeeding (BF) to ensure adequate Zn intakes
- Combine BF + DS & effective BCC that promotes ASFs to increase intakes of absorbable Zn & promote growth
- Include BF + DS + Nut Ed as integral part of *ALL* dietary guidelines
- Rigorously monitor & evaluate DS to assess *how* DS have worked & whether there is a positive effect on Zn status & Zn-related health outcomes
- Integrate all DS with programs addressing *underlying* causes of malnutrition:
  - poverty-alleviation; food security; income-generation

# Thank you!


Please visit the IZiNCG web site:
www.izincg.org