Rice Fortification: Making Rice More Nutritious Post-Harvesting

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Micronutrient Malnutrition: The Facts

Micronutrient malnutrition (Hidden Hunger) affects 2 billion people worldwide, and is one of the main causes of poor health and disability

- 842 million people are undernourished. That is 1 out of 8
- 162 million (27%) children worldwide are stunted
- 56% of all stunted children live in Asia
- 300,000 newborns are born with neural tube defects annually
- 190 million pre-school age children and over 19 million pregnant women are affected by vitamin A deficiency

1. The State of Food Insecurity in the World, 2013
Addressing Micronutrient Deficiencies: a Smart Investment

Top Investment Priorities:

- Bundled micronutrient intervention to fight hunger & improve education
- Malaria combination treatment
- Childhood immunization
- Deworming
- Tuberculosis treatment
- R&D to increase yield enhancements

“One of the most compelling investments – to get nutrients to the world’s undernourished”
Vernon Smith, Nobel Laureate economist

Investment in Nutrition:

- Break circle of poverty
- 1 US$ can result in return of up to 30 US$
- Increase country’s GDP by at least 2-3% annually
Hunger: the Invisible Impact

Burden of Knowledge

Evidence of Effects of Malnutrition

Brain neurons in normal 3-yr old

Brain neurons in malnourished 3-yr old

© 2007 Dr Fernando Monckeberg Barros, Universidad Diego Portales

The child is reported to have suffered from extreme neglect (abandono crónico) and the degree to which other factors such as social stimulation may have impacted this child are unknown.
Improving Micronutrient Intake

- **Supplementation**
- **Dietary diversification**
- **(Industrial) food fortification**
  - Staple foods (rice, flour, milk, oil, sugar)
  - Dairy (milk, yoghurt)
  - Condiments (salt)
- **Home fortification**
  - Micronutrient powder, spreads, crushable tablets
- **Bio-fortification**
  - Agricultural products like maize, cassava, sweet potato, rice, beans (non-GMO / GMO)
Why Fortify Rice with Micronutrients

Three **main benefits** of staple food fortification:

1. Improved Health
2. Increased Productivity
3. Economic Progress

- **Micronutrient malnutrition** is one of the main causes of poor health and disability

- **Rice** is the main staple for **3 billion people**, concentrated in developing countries. Rice fortification enables consumers to improve their micronutrient intake without changing their buying and eating habits

- Staple food fortification is a proven **cost effective strategy** to address micronutrient deficiencies (e.g. salt, flour and oil fortification)

- Time is right: next to the partners organizing the workshop rice fortification is supported by governments and key global organizations
Rice has the potential to fill an obvious gap in current fortification programs

Vitamin and mineral deficiencies are widespread in high rice-consuming countries

Top Rice Consuming Countries

Iron Deficiency, Women age 15-49

Vitamin A Deficiency, Children under 6

Source: FAO2002

Rice Fortification Requirements

Fortified Rice developed to:

- Make a good contribution to micronutrient intake
- Be safe, also at higher levels of consumption
- Be accepted by consumers – good taste, mouth feel and appearance
- Have good self life + handling requirements comparable to non-fortified rice
- Be indistinguishable from non-fortified rice

These principles are comparable to fortification of other staple foods and well described in the WHO/FAO guidelines on food fortification with micronutrients.
Requirements for successful rice fortification

- **Storage**
  - Stability during storage

- **Preparation**
  - Limited losses during preparation: washing, cooking, discarding excess water

- **Acceptability**
  - Acceptability to consumer: appearance (shape and colour), taste

- **Absorption**
  - Availability for absorption by the body

**Impacted by:** choice of fortificant forms, choice of fortificant mixture, fortification technology

**Efficacy**

**Effectiveness**
Which MN to add to rice?

As for maize and wheat flours:

- Iron
- Folic Acid
- Vitamin B12
- Vitamin A
- Zinc

For rice, also add MN lost through polishing:

- Thiamin
- Vitamin B6
- Niacin

Many others also possible, such as:

- Vitamin E
- Vitamin D
- Selenium
- Lysine

Possible, but:

- Riboflavin
- Beta-carotene
- Calcium
- Vitamin C
- DHA
- Iodine

De Pee S. Annals NY Acad Sci 2014
Challenge of homogeneity

Fortified kernels must match non-fortified rice in shape, size and color.

http://www.riceauthority.com/rice-varieties/

Rice varieties for sale at a shop in Viet Nam. Photo by Brian Waldron.
Rice Fortification Technologies & Terminology

Five main technologies available for rice fortification:
- Dusting - Used in USA, less suitable in Asia: results in significant micronutrient losses during rinsing, washing and cooking
- Coating
- Cold extrusion
- Warm extrusion
- Hot extrusion

Choice and/or combination depends on scale, consumer acceptability, rice landscape, etc.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fortificant</td>
<td>Selected micronutrient in a particular form to fortify selected food (e.g. rice, flour, salt)</td>
</tr>
<tr>
<td>Fortificant mix / premix</td>
<td>Blend that contains several fortificants (vitamins and minerals)</td>
</tr>
<tr>
<td>Fortified kernels</td>
<td>Rice grains fortified with the fortificant mix</td>
</tr>
<tr>
<td>Fortified rice</td>
<td>Non-fortified rice blended (mixed) with the fortified kernels (at 0.5 – 2% ratio; typically 1%)</td>
</tr>
</tbody>
</table>
Coating

- Nutrients are added in coating layer on the rice surface:
  - Several coating technologies; different performance of fortified kernel
  - Some rinse-resistant; some not
- Native rice variety can be coated
- Nutrients disperse in rice upon cooking; allows higher concentration of nutrients in fortified kernel

Examples of fortified rice made by blending coated kernels with non-fortified rice. Wright Group photo.

DSM and Wright Group research
Extrusion

- Broken rice grains can be used as starting material
- Micronutrients are equally distributed inside the fortified kernel
- Only few particles are on the surface, thus reducing exposure to environment and nutrient degradation
- Color impact from micronutrients depends on nutrient formulation
Fortified Rice – Rice Enriched with Vitamins & Minerals

- Fortifying rice with extrusion or coating technology is straightforward two-step process:

1. **Rice Mill**
   - Paddy rice

2. **Whole rice kernels**
   - Blending 0.5 – 2% ratio

3. **(Broken) rice kernels**
   - Adding vitamins & minerals

4. **Fortified kernels**
   - Fortified rice kernels are made to resemble non-fortified rice kernels
Rice Fortification – Implementation and Costs

Introduction phase
- Local evidence on acceptability
- Health needs assessment
- Logistical feasibility
- Value chain analysis
- Policy development
- Project management

Core cost components of rice fortification
1: Production of fortified kernels (FK)
2: Transport of FK to point of blending
3: Blending of FK with normal rice
4: Sales or distribution of fortified rice
5: Quality control and assurance (QA & QC)
6: Additional planning

Scale-up phase
- Greater efficiency in supply chain
- Social marketing; advocacy
- Economies of scale
- Commercialization

Cost to fortify rice in school meal (lunch) for entire year is approx. 0.20 – 0.80 US$ per child
## Impact of Fortifying Rice with different Micronutrients – 15 published papers

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Fortificant forms</th>
<th>No. of studies that included the micronutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>MFPP (ferric pyrophosphate) / FeSO4</td>
<td>14 / 1</td>
</tr>
<tr>
<td>Zinc</td>
<td>Zinc oxide</td>
<td>1</td>
</tr>
<tr>
<td>Folic acid</td>
<td>Folic acid</td>
<td>1</td>
</tr>
<tr>
<td>Vit B12</td>
<td>Cyanocobalamin</td>
<td>1</td>
</tr>
<tr>
<td>Vit A</td>
<td>Vit A palmitate</td>
<td>4</td>
</tr>
<tr>
<td>Thiamin</td>
<td>Thiamin</td>
<td>2</td>
</tr>
<tr>
<td>Niacin</td>
<td>Niacinamide</td>
<td>0</td>
</tr>
<tr>
<td>Vit B6</td>
<td>Pyridoxine hydrochloride</td>
<td>1</td>
</tr>
</tbody>
</table>
Characteristics of 15 published papers

Study populations:

- Philippines, India, Thailand, Nepal, Brazil, Mexico
- School-age children, women of reproductive age, preschoolers, 6-23 mo old children
- Some studies targeted anemic individuals

Important to note:

- First study ‘47-’49, Philippines, coated rice, iron, B1, B3 – focused on beri-beri
- All other studies on extruded rice (hot & cold)
- 13 Efficacy, 2 effectiveness studies
- 10 studies on Fe only, 4 multi-MN, 1 VA only
- School children, one meal per day
## Summary: Evidence on which MN can be added and improves status

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Notes on Evidence</th>
</tr>
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<tbody>
<tr>
<td>Iron</td>
<td>y</td>
</tr>
<tr>
<td>Zinc</td>
<td>±</td>
</tr>
<tr>
<td>Folic acid</td>
<td>y</td>
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<tr>
<td>Vit B12</td>
<td>y</td>
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<td>y</td>
</tr>
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<td>Thiamin</td>
<td>y</td>
</tr>
<tr>
<td>Niacin</td>
<td>-</td>
</tr>
<tr>
<td>Vit B6</td>
<td>-</td>
</tr>
</tbody>
</table>
Summary of impact on MN status

Evidence for impact on MN status:

- Good enough for: Iron, vit A, folic acid, thiamin, vit B12
- Plausible for: Niacin
- To be confirmed for: Zinc, vit B6

Research for further optimization:

- Iron form – higher absorption, while maintaining good acceptability
- Study multi-MN fortified rice & different technologies
- Scenario’s: every meal from fortified rice, e.g. social safety net
Conclusions

- Rice fortification is a good way to increase MN intake, provided it is well fortified - sensory performance and nutrient level - and is consumed in adequate quantities, by populations in need.

- MN are small part of cost of fortified rice: fortify with MN that are likely lacking in the diet and for which evidence of impact is accumulating: proposal for 8 MN (iron, zinc, folic acid, vit B12, vit A, thiamin, niacin, vit B6)

- Use technology and fortification forms that are acceptable for consumer, stay in the rice and are absorbed by the body.

Wanting to know whether rice fortification makes a difference?

1. Monitor implementation – fortified rice has to reach people
2. Assess contribution to MN intake – high enough?
3. Monitor nutritional status & health, amidst real life circumstances