Rice Fortification: Why, What, How and Global Evidence

5 November, 2014
2nd International Workshop on Micronutrients and Child Health
New Delhi
Content

Provide a summary of the evidence on rice fortification and rationale for it being part of the solution to micronutrient deficiencies

Provide update on WFP’s work in nutrition for MNCH

1. Why, What and How
2. Summary of the current evidence
3. Way forward, including challenges and next steps
Building Consensus on Rice Fortification

- Technical Consultation meeting organized by WHO in collaboration with GAIN for Rice Fortification in Public Health, September 2012

Review the industrial and regulatory technical considerations in rice fortification
Scaling Up Rice Fortification in Asia, hosted by FFI, PATH, WFP, MI, UNICEF and GAIN

Consensus:

1. Evidence of widespread micronutrient deficiencies

2. Rice consumption is high

3. There are different technologies that can be used to fortify rice, of which extrusion is the best researched

4. Evidence of impact for a number of nutrients

5. We should build on existing cereal fortification guidelines, including the interim statement on flour fortification
Why rice fortification?

- Large % of the population relies on rice as the main staple food
- Rice provides a large share of caloric intake (50-70%)
- MNDs are high in rice-consuming areas
- Polished rice is a poor source of key vitamins and minerals
- Fortification has been identified as a very cost effective intervention
- Technology now exists
‘Rice’ Fortification
Does micronutrient (MN) intake need to be increased & selecting the vehicle

Micronutrient fortification may be appropriate if...

- Evidence indicates presence of **MN deficiencies**
- Deficiencies are to large extent caused by **low intake**
- MN deficiencies exists among **general population**

- **Consumed by large part of population**
- **Centrally processed**
- **Premix can be added easily and cheaply**
- **Suitable Vehicle**
  - May include cereals (wheat, corn, rice), oils, dairy products, beverages and various condiments such as salt, sauces (e.g. soy sauce) and sugar
- **Consumed on a regular basis**
Other ways to improve micronutrient content of rice

- Iron
- Zinc
- Thiamin
- Niacin
- Vitamin B6

[Bar chart showing micronutrient content in rice varieties: milled rice, brown rice, parboiled white rice, and fortified rice.]
Available technologies

Coating

Extrusion
  – Cold
  – Warm
  – Hot

Biofortification

Saman Rice Mill in Uruguay. Photo by Angela Rowell.
Objective of rice fortification?

- For staple food fortification, the target is getting consumers above the Estimated Average Requirement.
- Improved micronutrient intake, but not eliminate all MNDs.
- Who has high needs, who is likely to benefit from fortified rice?
  - WRA, adolescent girls, men, SAC.
  - PLWs will benefit but not meet needs.
  - 6-23 months need more nutrient dense foods.
Which MN to consider for rice fortification & ensuring it is effective

Consider wider food fortification expertise & experience

Which micronutrients are of interest?
- Consider public health needs and nutrient gap
- Refer to WHO’s guidelines on food fortification and interim consensus statement on flour fortification
- Compare maize and wheat flour fortification to rice

Can micronutrients be successfully added to rice and absorbed by the body?
Several requirements for successful rice fortification

- **Storage**
- **Preparation**
- **Acceptability**
- **Absorption**

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

**Stability during storage**

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

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

**Availability for absorption** by the body

**Efficacy**

**Effectiveness**
Which Micronutrients 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
## Impact of fortifying rice with different MN – 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 Study Populations

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
## Impact of fortifying rice with different MN – study results

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Study details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Iron</strong></td>
<td>14 studies</td>
</tr>
<tr>
<td><strong>Zinc</strong></td>
<td>1 – Pinkaew (2014) – Thailand – 20 mg/meal, <strong>non-sign increase</strong></td>
</tr>
<tr>
<td><strong>Folic acid</strong></td>
<td>1 – Thankachan (2012) – India – 75 ug/meal, <strong>sign decrease of homocysteine</strong></td>
</tr>
<tr>
<td><strong>Vit B12</strong></td>
<td>1 – Thankachan (2012) – India – 0.75 ug/meal, <strong>sign increase of plasma B12</strong></td>
</tr>
<tr>
<td><strong>Vit A</strong></td>
<td>4 studies</td>
</tr>
<tr>
<td><strong>Thiamin</strong></td>
<td>Salcedo (1950) – Philippines – 0.44 mg/100 g – <strong>beri beri prevalence dropped</strong> (14.3 to 1.5%); Thankachan (2012) – India – 0.38 mg/meal – <strong>non-sign increase</strong></td>
</tr>
<tr>
<td><strong>Niacin</strong></td>
<td>- 0 studies</td>
</tr>
<tr>
<td><strong>Vit B6</strong></td>
<td>- 1 study, but B6 status not assessed</td>
</tr>
</tbody>
</table>
## Studies on Vitamin A fortified rice

<table>
<thead>
<tr>
<th>Reference</th>
<th>Country</th>
<th>Study group</th>
<th>Dosage</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinkaew 2014</td>
<td>Thailand</td>
<td>8-12 y olds</td>
<td>3000 RE/d</td>
<td>BL serum retinol 1.21 umol/L – total body retinol increased – BL serum retinol unchanged</td>
</tr>
<tr>
<td>Pinkaew 2013</td>
<td>Thailand</td>
<td>4-12 y old</td>
<td>2500 RE/d</td>
<td>BL serum retinol 1.01 umol/L - No sign increase</td>
</tr>
<tr>
<td>Thankachan 2012</td>
<td>India</td>
<td>6-12 y old</td>
<td>500 RE/d</td>
<td>BL serum retinol 2.1-2.6 umol/L – No change</td>
</tr>
<tr>
<td>Haskell 2003</td>
<td>Nepal</td>
<td>Nightblind pregnant women</td>
<td>850 RE/d</td>
<td>Serum retinol increased in all groups, most in liver &amp; high-dose capsule groups</td>
</tr>
</tbody>
</table>

**Conclusion:** Improvement of VA status depends on baseline status & indicator used
Studies on Iron Fortified Rice

Characteristics:

• 13/14 studies MFPP, 1 study both MFPP & FeSO4
• 10 iron only fortification
• 3 papers, Arcanjo et al (Brazil), one 50 g meal/wk, 56.4 mg Fe
• Other studies 6-30 mg Fe/meal, mostly 1 meal/d – school children = efficacy
• More than one meal per day: 1 study – effectiveness, fortified rice given to households (Angeles-Agdepa 2011)
• Blending: 0.5-2.5%
• No reporting on color of kernels – controlled studies, no acceptability issue
• If blending at 1%, max iron content without color change: 7 mg/100 g. If consuming 200-300 g/d = 15-20 mg/d

Thus, mostly well-controlled studies, 1 meal/d among school children
Studies on iron fortified rice (n=14)

Results:
- 2 did not report on Hb or iron status
- Hb improvement / anemia decline – 6/12 studies
- Iron status parameters improved – 6/8 studies

Note:
- Hb not only affected by iron deficiency
- Baseline Hb not that low in some of the studies
- One meal per day studies have higher ratio for iron to absorption inhibitors – thus, under real life, iron absorption may be lower

Summary:
- Most found impact on iron status and anemia
- Studies mostly one-meal-per-day studies
- MFPP not most bioavailable iron fortificant, but only one that does not affect colour and taste
Summary of Evidence

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
When assessing PROGRAM impact – monitor process & outcome

<table>
<thead>
<tr>
<th>Fortification</th>
<th>Distribution</th>
<th>Consumption</th>
<th>MN retention</th>
<th>MN status &amp; function</th>
</tr>
</thead>
</table>

- Is rice fortified as agreed (QA & QC)?
- Does rice reach the population as intended?
- Do people consume the rice at expected level?
- Does the rice contain the expected MN at consumption?
- Does MN status and function (morbidity, cognition) improve?

Effectiveness
Is fortified rice acceptable?

Acceptability Scores for Fortified and Non-fortified Rice: Sensory Evaluation by Indian Children 8-11 Years

Radhika 2011; extruded rice
Are the nutrients in fortified rice retained after preparation and cooking?

Percent Retention of Nutrients Exposed to Different Preparation and Cooking Methods: Average for Coating, Cold Extrusion & Hot Extrusion

<table>
<thead>
<tr>
<th>Method</th>
<th>Retention</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 min soaking before boiling in excess water and discarding water</td>
<td>Excess + soaking</td>
</tr>
<tr>
<td>Boiling in excess water and discarding water</td>
<td>Excess</td>
</tr>
<tr>
<td>Boiling and letting rice absorb water</td>
<td>Boiling</td>
</tr>
<tr>
<td>Washing before boiling and letting rice absorb water</td>
<td>Boiling + washing</td>
</tr>
<tr>
<td>Frying before boiling and letting rice absorb water</td>
<td>Frying</td>
</tr>
</tbody>
</table>

Wieringa 2014
Next Steps – Opportunities and Further Work

- Significant progress has been made
- Growing interest and consensus among many stakeholders
- Important opportunity to address micronutrients

- Complexity of implementation
- Kernel availability
- Local production and small-scale milling
- Policy and regulation – leadership and a coalition
- Optimization of fortificants: ongoing, especially for iron, and these findings can be incorporated when available
- Costs – who picks up the additional costs -- Cost-benefit
Thank you and Acknowledgements

Saskia de Pee, WFP
Megan Parker, PATH
Helena Pachón, FFI
Scott Montgomery, FFI
Parboiling – indirect fortification

- Treating with hot water and/or steam enhances intrinsic nutrients
- Additional nutrients not usually included
- Efforts to get external nutrients into the grain (iron, zinc, folic acid) have been studied

DSM research and C. Prom-u-thai, 2011
Dusting

- All rice grains dusted with a fortificant mix
- Limited nutrient protection
- Sedimentation risk
- Frequently done in USA
- Due to nutrient loss, not suitable in countries where rice is washed or where excess cooking water is discarded
Overview: creating fortified kernels to blend with non-fortified rice grains

Applies to coating and extrusion

Chart adapted from Steiger 2012
Coating

- Nutrients are added in coating layer on the rice surface
  - Several coating technologies; different performance of FK
  - Some rinse-resistant; some not
- Native rice variety can be coated
- Either broken or whole grains can be coated
- Nutrients disperse in rice upon cooking; allows higher concentration of nutrients in FK

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

1. Broken rice grains can be used as starting material
2. Micronutrients are equally distributed inside the fortified kernel
3. Only few particles are on the surface, thus reducing exposure to environment and nutrient degradation
4. Color impact from micronutrients depends on nutrient formulation
Extrusion technologies

Temperature influences appearance and cooking characteristics of final fortified kernels

- Cold extrusion uses a pasta press at 30 – 50°C
- Warm extrusion includes a preconditioner and uses a pasta press or extruder (single or double) at 60 – 80°C
- Hot extrusion includes a preconditioner and uses an extruder (single or double) at 80 – 110°C
Basic extrusion steps

Rice flour  Premix  Additives

Dry mixing

Water Steam

Conditioning

Dough formation

Shaping

Stabilising

Drying

Fortified Rice Kernels

Raw Materials

Ingredients

Milling

Pre-conditioning

Extruder

DSM research
Appearance of fortified kernels

From: Steiger et al. 
Fortification of rice: technologies & nutrients. NY Anals 2014