Overview of Trials and Evidence

Is rice a good vehicle for micronutrient fortification?

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Conclusions

• Rice fortification is a good way to increase MN intake, provided it is well fortified 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

• …..
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**

**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

- **Premix can be added easily and cheaply**
- **Centrally processed**
- **Consumed by large part of population**
- **Consumed on a regular basis**

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

<table>
<thead>
<tr>
<th>Storage</th>
<th>Preparation</th>
<th>Acceptability</th>
<th>Absorption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stability during storage</td>
<td>Limited losses during preparation: washing, cooking, discarding excess water</td>
<td>Acceptability to consumer: appearance (shape and colour), taste</td>
<td>Availability for absorption by the body</td>
</tr>
</tbody>
</table>

**Impacted by:** choice of fortificant forms, choice of fortificant mixture, fortification technology
Which MN to add to rice?

As for maize and wheat flours:
- Iron
- Folic Acid
- Vitamin B12
- Vitamin A
- Zinc

Many others also possible, such as:
- Vitamin E
- Vitamin D
- Selenium
- Lysine

For rice, also add MN lost through polishing:
- Thiamin
- Vitamin B6
- Niacin

Commonly added in large scale programs:
- Riboflavin
- Beta-carotene
- Calcium
- Vitamin C
- DHA
- Iodine

Possible, but:
- Vitamin E
- Riboflavin
- Beta-carotene
- Calcium
- Vitamin C
- DHA
- Iodine

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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 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
# Impact of fortifying rice with different MN – study results

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Study details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>14 studies</td>
</tr>
<tr>
<td>Zinc</td>
<td>± 1 – Pinkaew (2014) – Thailand – 20 mg/meal, <strong>non-sign increase</strong></td>
</tr>
<tr>
<td>Folic acid</td>
<td>y 1 – Thankachan (2012) – India – 75 ug/meal, <strong>sign decrease of homocysteine</strong></td>
</tr>
<tr>
<td>Vit B12</td>
<td>y 1 – Thankachan (2012) – India – 0.75 ug/meal, <strong>sign increase of plasma B12</strong></td>
</tr>
<tr>
<td>Vit A</td>
<td>4 studies</td>
</tr>
<tr>
<td>Thiamin</td>
<td>Salcedo (1950) – Philippines – 0.44 mg/100 g – <strong>beri beri prevalence dropped</strong> (14.3 to 1.5%); 1 – Thankachan (2012) – India – 0.38 mg/meal – <strong>non-sign increase</strong></td>
</tr>
<tr>
<td>Niacin</td>
<td>- 0 studies</td>
</tr>
<tr>
<td>Vit B6</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

Thus: * 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: Evidence on which MN can be added and improves status**

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Notes on Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>MFPP showed impact at high blending ratio + relatively high content in one meal per day – exploring other iron fortificants in research</td>
</tr>
<tr>
<td>Zinc</td>
<td>1 study – not confirmed, but same for other Zn fortification studies – questions about serum zinc as indicator</td>
</tr>
<tr>
<td>Folic acid</td>
<td>1 study – confirmed, in-line with flour fortification results</td>
</tr>
<tr>
<td>Vit B12</td>
<td>1 study – confirmed – is also added to wheat flour</td>
</tr>
<tr>
<td>Vit A</td>
<td>4 studies – improved VA status confirmed (status dependent)</td>
</tr>
<tr>
<td>Thiamin</td>
<td>2 studies – confirmed late 1940’s for beri-beri</td>
</tr>
<tr>
<td>Niacin</td>
<td>Not studied, but commonly added because lost during polishing</td>
</tr>
<tr>
<td>Vit B6</td>
<td>Not yet studied</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
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>
<tbody>
<tr>
<td>Is rice fortified as agreed (QA &amp; QC)?</td>
<td>Does rice reach the population as intended?</td>
<td>Do people consume the rice at expected level?</td>
<td>Does the rice contain the expected MN at consumption?</td>
<td>Does MN status and function (morbidity, cognition) improve?</td>
</tr>
</tbody>
</table>

Effectiveness
Conclusions

• Rice fortification is a good way to increase MN intake, provided it is well fortified 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
Thank you
Terima kasih
धन्यवाद
Salamat Po
ধন্যবাদ
Terima kasih
धन्यवाद
Thanks