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
- …..

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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

Consumed on a regular basis

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

Centrally processed

Premix can be added easily and cheaply

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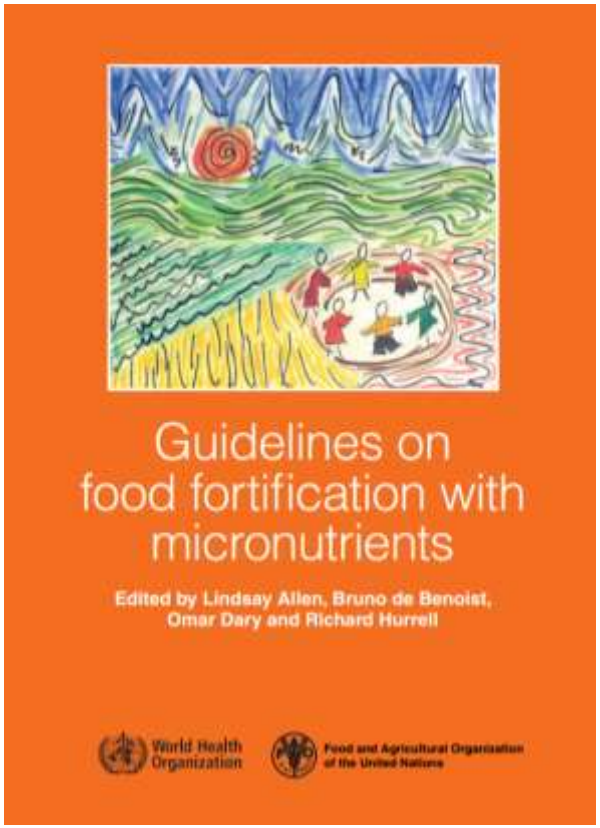
Which MN to consider for rice fortification & ensuring it is effective



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?

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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 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

Commonly added in large scale programs

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

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Impact of fortifying rice with different MN – 15 published papers

Micronutrient	Fortificant forms	No. of studies that included the micronutrients
Iron	MFPP (ferric pyrophosphate) / FeSO4	14 / 1
Zinc	Zinc oxide	1
Folic acid	Folic acid	1
Vit B12	Cyanocobalamin	1
Vit A	Vit A palmitate	4
Thiamin	Thiamin	2
Niacin	Niacinamide	0
Vit B6	Pyridoxine hydrochloride	1

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

Micronutrient		Study details
Iron		14 studies
Zinc	±	1 – Pinkaew (2014) – Thailand – 20 mg/meal**, non-sign increase**
Folic acid	y	1 – Thankachan (2012) – India – 75 ug/meal, **sign decrease of homocysteine**
Vit B12	y	1 – Thankachan (2012) – India – 0.75 ug/meal, **sign increase of plasma B12**
Vit A		4 studies
Thiamin	y	Salcedo (1950) – Philippines – 0.44 mg/100 g **– beri beri prevalence dropped** (14.3 to 1.5%); Thankachan (2012) – India – 0.38 mg/meal – **non-sign increase**
Niacin	-	0 studies
Vit B6	-	1 study, but B6 status not assessed

Studies on Vitamin A fortified rice

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

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

Micronutrient		Notes on Evidence
Iron	y	MFPP showed impact at high blending ratio + relatively high content in one meal per day – exploring other iron fortificants in research
Zinc	±	1 study – not confirmed, but same for other Zn fortification studies – questions about serum zinc as indicator
Folic acid	y	1 study – confirmed, in-line with flour fortification results
Vit B12	y	1 study – confirmed – is also added to wheat flour
Vit A	y	4 studies – improved VA status confirmed (status dependent)
Thiamin	y	2 studies – confirmed late 1940's for beri-beri
Niacin	-	Not studied, but commonly added because lost during polishing
Vit B6	-	Not yet studied

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

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When assessing PROGRAM impact – monitor process & outcome

Fortification	Distribution	Consumption	MN retention	MN status & function
				
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

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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

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