Efficacy and effectiveness evidence on fortified rice: Global and Indian

There is an available pool of 17 international scientific studies (including 4 from India) conducted on infants, children and women demonstrating the efficacy and effectiveness of fortified rice (using extrusion technology) in improving micronutrient status. Of these, 17 studies (4 from Brazil and India each, 3 from Thailand, 2 from Nepal and Philippines each and 1 from Cambodia and Mexico each). Key findings from these 17 studies that investigated the efficacy of fortified rice in improving iron status in different age groups are as follows -

- ***Effect on Hb[1] level:*** From a total of 15 studies, six studies reported significant increase in Hb levels.
- ***Effect on ferritin[2] levels:*** From a total of 10 studies, seven studies reported significant increase in serum ferritin levels.
- ***Prevalence of anaemia[3]:*** From a total of 10 studies, eight reported significant reduction in prevalence of anaemia after consumption of fortified rice.
- ***Prevalence of iron deficiency[4]:*** From the total of eight studies, which investigated the effect of consumption of fortified rice on iron deficiency, six reported significant reduction in iron deficiency.

Seven studies also investigated the effect of fortified rice on other micronutrient levels in the body –

- ***Effect on Vitamin A levels[5]:*** From a total of five studies, three studies reported significant increase in serum retinol levels.
- ***Effect on zinc status[6]:*** From a total of three studies, one study reported significant increase in serum zinc levels.
- ***Effect on vitamin B12[7] levels:*** Only one study investigated plasma B12 levels and reported significant increase.

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[1]*Anaemia is defined as Hb level: <11.5g/dL in children 5-11 years; <12g/dL in children ≥12 years; <11 g/dL during pregnancy*

[2]*Iron deficiency (ID) is when serum ferritin levels fall <15mcg/L*

[3]*Number of study subjects suffering from anaemia i.e. blood Hb levels below cut-off values*

[4]*Number of study subjects having serum ferritin below <15mcg/dL*

[5]*Assessed by serum retinol levels*

[6]*Assessed by serum zinc levels*

[7]*Assessed by serum B12 levels*

S.No	Author	Country	Study Population	Intervention period	Composition	Effect on iron parameters	Effect on other micronutrient parameters
1.	Perignon (2016)	Cambodia	6-16 year old children (2440)	6 months	Iron, zinc, vitamin B1, folic acid, vitamin A, vitamin 12, vitamin B3 and vitamin B6	At three months significant increase in Hb level but no significant changes at 6 months. Increase in ferritin levels.	Significant increase in serum Vitamin A levels.
2.	Pinkaew (2014)	Thailand	8-12 years (50)	2 months	Iron, zinc and vitamin A		Significant increase in serum Vitamin A levels.
3.	Pinkaew (2013)	Thailand	4 - 12 year old school children, 101 in fortified group, 102 in control group)	5 months	Zn, Iron, Vitamin A (10 mg Fe, 9 mg Zn, and 1.05 mg VA/g extruded rice). Control group received equal amount of non-fortified rice.	Increase in serum zinc and serum ferritin. Marked decrease in iron deficiency.	No significant increase in serum zinc and serum retinol.
4.	Arcanjo (2013)	Brazil (Sobral)	Preschoolers 2-5y (303)	18 weeks	Micronized ferric pyrophosphate (weekly ingestion of 56.4 mg of iron in each 50 g portion). Control group received non-fortified rice	Increase in Hb levels	
5.	Arcanjo (2013)	Brazil (Sobral)	Infants 10-23 months (171)	18 weeks	Micronized ferric pyrophosphate (weekly ingestion of 56.4 mg of iron in each 50 g portion). Control group received non-fortified rice	Increase in haemoglobin levels. Decrease in anaemia prevalence.	
6.	Thankachan (2012)	India	6-12 year old children (258)	6 months	Vitamin A, thiamine, niacin, vitamin B6, vitamin B12, folate, iron and zinc	Increase in haemoglobin and decrease in anaemia prevalence but no change in ferritin	Increase in plasma B12 levels but no effect on serum zinc and serum retinol and blood thiamine levels.

S.No	Author	Country	Study Population	Intervention period	Composition	Effect on iron parameters	Effect on other micronutrient parameters
7.	Arcanjo (2012)	Brazil (Moreanos)	Infants 10-23 months (216)	18 weeks	Micronized ferric pyrophosphate (weekly ingestion of 56.4 mg of iron in each 50 g portion). Control group received non-fortified rice	Increase in haemoglobin levels. Decrease in anaemia prevalence.	
8.	Angeles-Agdeppa (2011)	Philippines	Mothers (766) and their children 6-9 years	9 months	Microionized dispersible ferric pyrophosphate (600-760mg/100g); 1-2 mg Fe/100 g of cooked rice.	Increase in haemoglobin and decrease in anaemia prevalence.	
9.	Radhika (2011)	India	5-11 year old children (140)	8 months	Microionized ferric pyrophosphate (19mg Fe/d)	Increase in serum ferritin, decrease in prevalence of iron deficiency.	
10.	Beinner (2010)	Brazil (Belo Horizonte)	Mildly anemic 6-24 month year old children (175: 84 received fortified rice, 81 received non-fortified rice with iron drops)	5 months	Micronized ferric pyrophosphate (MFP) (10.4mg Fe/g MFP-designed to deliver 23.4 mg Fe/d). Comparison group received 20 drops of iron solution (ferrous sulfate) 3x weekly (10 mg Fe/d). Designed to provide participants in each group with equal amounts of absorbed iron.	Increase in haemoglobin and serum ferritin, decrease in anaemia prevalence and iron deficiency.	
11.	Angeles-Agdeppa (2008)	Philippines	6-9 year old children (180)	6 months	Ferrous sulphate to one group, Micronized dispersible ferric pyrophosphate	Increase in Hb levels, decrease in anaemia prevalence and no change in plasma ferritin	No significant increase in plasma retinol levels.

S.No	Author	Country	Study Population	Intervention period	Composition	Effect on iron parameters	Effect on other micronutrient parameters
12.	Hotz (2008)	Mexico	Non-pregnant, non-lactating women (18-49 years) (70 controls and 75 fortified group)	6 months	Micronized ferric pyrophosphate (20mgFe/day)	Increase in plasma ferritin, iron stores and Hb level, decrease in anaemia prevalence and iron deficiency.	
13.	Graham (2007)	Nepal	Night blind pregnant women (106)	6 weeks	Retinyl palmitate, Fe (30 mg-provided via capsule), riboflavin (6 mg--provided via capsule). Control group received vitamin A only.	Decrease in iron deficiency anaemia, increase in erythrocyte riboflavin levels and increase in plasma ferritin.	
14.	Moretti (2006)	India	6-13 year old children (184)	7 months	Microionized ground ferric pyrophosphate (200mg Fe/kg rice)	Increase in serum ferritin, increase in body iron stores and no changes in haemoglobin	
15.	Zimmermann (2006)	India	School age children (5-9 years) and night blind pregant women (134)	4 months	Micronized ferric pyrophosphate (10 mg iron/g of extruded rice). Control group received non-fortified rice	Increase in serum ferritin, decrease in iron deficiency.	Significant increase in zinc levels.
16.	Haskell (2005)	Nepal	Pregnant women (18-45 years) (348)	6 weeks	Retinyl palmitate		Significant increase in plasma retinol.
17.	Gershoff (1977)	Thailand	Children 1.5 – 9 years (2250)	1-4 years	Rice fortified with thiamine, riboflavin, retinol acetate, iron, lysine and threonine	No significant changes in Hb	

Note: Two studies were excluded from this summary – 1. Salcedo (1950) which reported significant decrease in prevalence of Beri-beri cases but fortified rice were produced by coating technology. 2. Bagni (2009) which reported significant increase in Hb levels and decrease in anaemia prevalence but rice was fortified using iron drops.

Fortification has been effective in reducing the burden of Neural Tube Defects (NTD[8]).

In India, prevalence of NTD is around 40 per 10,000 births which is much higher as compared to America which is 11.5 per 10,000 births, 6.9 per 10,000 in Western Pacific and 9 per 10,000 birth in European region (Bhide et al. 2013 and Zaganjor et al. 2016).

There is emerging evidence that folic acid fortification reduces both the incidence and the severity of NTDs (Bol et al. 2006 and Cotter and Daly, 2005); as studies suggests that food fortification can reduce the incidence of NTDs by 46 percent (37–54 percent).

Canada, South Africa, Costa Rica, Chile, Argentina, and Brazil have reported declines in NTDs ranging from 19 – 55 percent since the initiation of folic acid food fortification. Systematic review of 31 studies where flour fortified with varying levels (40-500mcg/100g) showed significant impact in reducing NTD's (Das et al. 2013).

Data suggest that a prevalence of 5–6 cases per 10,000 pregnancies represents the lowest prevalence that is achievable through current folic acid fortification practices and that a proportion of the remaining NTDs are not sensitive to folic acid [CDC, 2010 and Berry et al. 2010]. Data from countries that track NTDs generally find that their NTD prevalence drops to less than 10 per 10,000 live births after they begin fortifying flour with folic acid (Zimmerman, 2011).The introduction of the mandatory fortification of flour with iron and folic acid in Brazil was followed by a significant reduction in the prevalence of neural tube defects from 0.79 per 1000 pre-fortification to 0.55 per 1000 post-fortification and stillbirths prevalence fell from 17.74 per 1000 stillbirths pre-fortification to 11.70 per 1000 stillbirths post-fortification (Santos et al. 2015).

Rice fortification can play a critical role in reducing folic acid deficiency in areas where it is a major staple.

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[8]Neural tube defects (NTDs) are birth defects of the brain, spine, or spinal cord. They happen in the first month of pregnancy. Folate deficiency in women is a risk factor for NTD in children.

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