Biofortification: A food-based strategy to help reduce the disease burden associated with iron deficiency

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What is biofortification?

- An **agricultural-nutrition intervention** that uses conventional breeding, agronomic, and transgenic techniques to increase the density of vitamins and minerals in staple food crops.

- It has been shown to be an effective way to **use plant-based foods to deliver more micronutrients** to malnourished populations.

- It is a **cost-effective** and **sustainable** strategy based on familiar and readily available foods.

- Biofortified crops are **developed** with CGIAR partners, **tested** in partnership by NARS and **released** by the national governments.
Biofortification has become a core nutrition strategy

A nourishing, diverse diet is the ideal nutrition strategy as long as people can afford and access the right mix of foods.

- **Biofortification** of staple foods (upfront investment)
- **Fortification** added to foods (sustained investment)
- **Supplementation** Consumed as pills, powders, drops, etc. (sustained investment)
Iron biofortified crop releases

**IRON PEARL MILLET**
11 varieties in 2 countries in Africa and Asia
- India
- Niger

**IRON BEANS**
65 varieties in 14 countries in Latin America and Africa
- Bolivia
- Brazil
- Colombia
- El Salvador
- Guatemala
- Honduras
- Nicaragua
- Panama
- Burundi
- DRC
- Rwanda
- Tanzania
- Uganda
- Zimbabwe
Iron biofortification of staple crops

**the role of HarvestPlus**
HarvestPlus works with partners to develop and promote iron-biofortified bean and iron pearl millet.

**what are they**
crops developed through conventional plant breeding to increase iron levels.

**who they target**
resource-poor households or rural communities who rely on staple crops for much of their diet; high-risk groups, such as women, adolescent girls, young children.

**nutritional benefits**
iron-biofortified crops aim to provide an additional 30% of the estimated average iron requirement.
Research history of iron biofortified crops

CROP DEVELOPMENT
Biofortified crops with at least 50% more iron successfully developed & released

DIETARY INTAKE & NUTRITIONAL STATUS
Target populations identified & staple food consumption for iron crops determined

NUTRIENT RETENTION
The effect of common processing methods on iron retention determined

BIOAVAILABILITY
Absorption of iron from biofortified crops measured

EFFICACY / EFFECTIVENESS
Nutrition & health effects of iron-biofortified crops established in real-world settings

DISCOVERY
DEVELOPMENT
DELIVERY
When consumed, can the increase in iron make a significant impact on human nutrition?
Impact of pearl millet in India

Consumption of iron pearl millet significantly improved:

• Iron status (serum ferritin & TBI) after 4-mo
• Iron deficiency by 6-mo
• Cognitive function; higher scores in perception abilities, attention and memory functions
• Physical activity

Source: Finkelstein et al., 2015; Scott et al., 2018; and Pompane et al (in-press)
Impact of iron-beans in Rwanda

Consumption of iron beans significantly improved:

• Iron status (serum ferritin, TBI, and Hb) after 4.5 mo
• Cognitive function; speed and efficiency of memory and attention tasks
• Behavioral performance and brain activity
• Significant relationship between iron status and work capacity

Source: Hass JD et al, 2016; Murray-Kolb et al., 2017; Wenger et al., 2019; and Luna et al, 2020
Meta-analysis on iron biofortification

- **Serum ferritin**
  - Philippines: 17.94% ± 0.31 [-5.22, 5.84]
  - India: 22.88% ± 0.62 [-4.27, 5.52]
  - Rwanda: 59.20% ± 3.81 [0.77, 6.85]

- **Total Body Iron**
  - Summary Estimate: 100.00% ± 2.45 [0.11, 4.60]
  - 25.26% ± 0.09 [-0.08, 0.25]
  - 23.79% ± 0.05 [-0.11, 0.22]
  - 50.96% ± 0.12 [0.01, 0.24]

- **Hemoglobin**
  - Summary Estimate: 100.00% ± 0.10 [0.02, 0.18]
  - 18.12% ± 0.42 [-0.35, 1.19]
  - 26.65% ± 0.23 [-0.36, 0.91]
  - 55.03% ± 0.50 [0.06, 0.94]

Conclusions:

- **Iron-biofortification is efficacious in improving iron status**, particularly in iron deficient populations.
- Variation in response to consuming iron crops depend on a combination of factors:
  - Iron content of staple
  - Differential of iron content between high iron and control staple
  - Amount of staple food consumed over the entire feeding period
  - Time (feeding days) to see a measurable effect
  - Iron status of the study sample

Are farmers willing to grow & are consumers willing to eat iron-biofortified crops?
Households growing iron biofortified crops

- **Global Reach Iron Beans**
- **India Iron Pearl Millet**

**Year**
- 2014: 61,000
- 2015: 89,000
- 2016: 74,000
- 2017: 92,000
- 2018: 93,000
- 2019: 238,000

**# of households growing**
- 2014: 912,000
- 2015: 1,140,000
- 2016: 1,300,000
- 2017: 1,700,000
- 2018: 1,900,000
- 2019: 2,300,000
What is the potential impact of biofortification at scale?
Simulating DALYs saved for Rwanda

- Average daily bean consumption, increased nutrient levels, retention and bioavailability are used to calculate the average daily additional amount of micronutrient supplied by biofortification.

- We then calculate how much biofortification lowers disease incidence rates (expressed as Disability-Adjusted Life Year (DALY)).

- A standard value of $1000 is applied to each DALY to convert DALY saved to a monetary benefit.

Simulating DALYs saved for Rwanda

**Observed**

(2010-2018)

20% HIB production in 2018

- $4.9 mil
  - Value of reduced iron deficiency

**Simulated**

(2010-2025)

Scenario 1: Observed HIB production

- $16.2 mil
  - Value of reduced iron deficiency

Scenario 2: 40% HIB production

- $22.3 mil
  - Value of reduced iron deficiency

How do these DALY benefits translate back to disease incidence rates?

If the population eats 40% of its beans as iron biofortified beans then:

• The annual burden of iron deficiency in DALYs would be reduced by 30.6%; and

• Impaired physical activity due to iron-deficiency anemia among children <5y and women 15-49y would be reduced by 20% and 16%, respectively.

Biofortified crops have been released and/or are in testing in the countries shaded in blue on the map.
THANK YOU!

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