Assessing potential for parboil rice fortification with zinc

Nutritious Rice Value Chain Project
Micronutrient malnutrition results in an estimated US$1 billion loss in economic productivity in Bangladesh, annually.

Zinc deficiency is the most prevalent micronutrient deficiency in Bangladesh—affects 45% of preschool-age children and 57% of women.

Low dietary diversity is associated with inadequate nutrient intakes in Bangladesh.

Rice is widely consumed across the country. Upwards of 70% of calories are derived from milled rice (FAO, 2012).

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1 FANTA Bangladesh PROFILES, 2012
ADDITION AND MITIGATION OF LOSSES

Farm inputs

Production

Soaking/Parboiling

Milling

Cooking

Zinc biofortified rice germplasm

Zinc-fertilizer enriched rice

Fortify parboil soaking water with zinc

Nutrition-sensitive parboiling

Reduced milling

Extrusion fortification

Use optimal cooking water volume
**Objective:** Test interventions along the agricultural value chain to improve the nutritional density of rice in Bangladesh.
ESTIMATED INCREASE IN RICE GRAIN CONTENT (MG ZINC/ KG RICE) UPDATED

<table>
<thead>
<tr>
<th>Method</th>
<th>Range of values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fortificant soaking</td>
<td>11.7 – 11.8</td>
</tr>
<tr>
<td>Zinc fertilizer (soil)</td>
<td>0.1 - 6.0</td>
</tr>
<tr>
<td>Zinc fertilizer (foliar)</td>
<td>1.4 - 4.6</td>
</tr>
<tr>
<td>Reduced milling</td>
<td>2.4 - 4.0</td>
</tr>
<tr>
<td>Parboiling optimization</td>
<td>0.9 – 1.3</td>
</tr>
</tbody>
</table>

Source: GAIN Bangladesh Nutritious Rice Technical Assessment, 2013; Dalberg analysis.
### SUMMARY OF MARKET ASSESSMENT FOR EACH OF THE INTERVENTIONS CONSIDERED

<table>
<thead>
<tr>
<th>Positive rating</th>
<th>Negative rating</th>
<th>Increase in zinc content (zinc µg/g)(^1)</th>
<th>Evidence of demand (price impact)(^2)</th>
<th>Supply chain capacity</th>
<th>Regulatory environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>Fortification during parboiling</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>(6.0 to 23.4 µg/g)(^3)</td>
<td>(+1 to +1.5 Tk)</td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td></td>
<td>Reduced milling</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>(2.4 to 4.0 µg/g)(^4)</td>
<td>(-0.3 to -0.6 Tk)</td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td></td>
<td>Soil</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>(0.1 to 6.0 µg/g)(^5)</td>
<td>(+0 to +0.6 Tk)</td>
<td></td>
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<tr>
<td>4</td>
<td></td>
<td>Foliar</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>(1.4 to 4.6+ µg/g)(^5)</td>
<td>(+1.5 to +1.8 Tk)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Nutrition-sensitive parboiling</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>(0.9 to 1.3 µg/g)(^6)</td>
<td>(price increase)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
1. Increase in zinc content of milled, washed and cooked rice.
2. Demand assessment relies on multiple factors, impact on price is not the only dimension used for rating.
3. This is across all concentrations.
4. This is ranked lower because increased phytate levels in reduced milled rice decrease the ultimate nutritional impact of the concept.
5. Fertilizer values are based on literature review; for soil-based fertilizer, +0.1 µg/g of zinc is in zinc adequate soils, and +6.0 µg/g is in zinc deficient soils; for foliar fertilizer, the range is given for zinc adequate soils only; data does not exist for impact on zinc deficient soils, but is likely to be higher than soil-based ones.
6. This figure is not statistically significant and the rating is therefore lower.

**Source:** GAIN Bangladesh Nutritious Rice Technical Assessment, 2013; HarvestPlus; Interview with World Food Programme; Dalberg analysis.
PARBOIL FORTIFICATION: ADDITION OF SOLUBLE NUTRIENTS TO SOAKING WATER BEFORE PARBOILING

• 1950-1960’s: Approach first used in Japan to increase amino acid content of rice (*lysine* and *thiamin*)
  - Brown or milled rice soaked in an amino acid solution
  - Thiamin enrichment used at industrial level

• 2000’s: Prom-u-thai et al studies this process in depth for *iron* and *zinc*:
  - **1.4x increase** adding zinc at 50 mg/kg paddy (9.7 to 13.2 mg zinc/kg milled rice)
  - **4.5x increase** adding zinc at 400 mg/kg paddy (9.7 to 44.1 mg zinc/kg milled rice)
  - Use of low pH and hot temperature in soaking water to boost uptake (of iron)
  - Did not conduct industrial pilot tests in Thailand: parboiled rice is for export therefore not of national interest
ZINC CONTENT IN PARBOIL FORTIFIED RICE

Mg zinc / L or kg paddy

Zinc content (mg/kg paddy dry wt)

Cooked rice - low
Cooked rice - high

1.6x ↑
This amount of zinc in the milled rice represents only 2.2% of the zinc added to the system.
ZINC RETENTION IN PARBOIL FORTIFIED RICE AFTER WASHING AND COOKING

Zinc retention %

Retention (%)

Mg zinc / L or kg paddy
IMPACT OF ZINC PARBOIL FORTIFIED RICE ON THE PREVALENCE OF INADEQUATE ZINC INTAKES

- 300 mg zinc L-1
- 1300 mg zinc L-1

Baseline 15% 50% 80% Baseline 15% 50% 80%

Children 2-3 yrs Women

EARLY RESULTS INDICATE THERE IS DEMAND FOR NUTRITIOUS RICE

There are limited changes expected to the organoleptic properties of rice

Initial results indicate that there are limited changes in the smell, texture or taste of the rice either

Consumers are willing to pay a ~2 taka premium for nutritious rice

Control, open parboil

Fortified with 1300mg, open parboil

Initial results indicate that there are limited changes in the smell, texture or taste of the rice either

(1) The consumers were provided brief awareness / education via the survey question, which was: “If you were told that this rice (a) provided you and your family with vitamins (b) would help prevent diarrhea/other diseases for your family, particularly children; (c) made the children stronger, what would be the fair price for this rice?”

Source: GAIN technical tests in labs (November 2013); Interviews with experts; GAIN Bangladesh Consumer Survey, 2013; Dalberg analysis
FORTIFICANT SOAKED RICE IS EXPECTED TO BE 1-1.5TK/KG (~3-5% INCREASE) FALLING WITHIN CONSUMER WILLINGNESS TO PAY.

Source: GAIN Miller Survey 2013; Interviews with millers; Dalberg analysis.
Industrial Pilot Study

Small Scale (0.4 MT)

500 and 1100 mg zinc/kg paddy
INDUSTRIAL PILOT - SMALL SCALE ENGELBERG MILL VS LABORATORY STUDY

MILLED RICE - RAW

Engelberg study - 2015

- Control
- 500 mg Zn/kg paddy
- 1100 mg Zn/kg paddy

Laboratory study 2013

- Control
- 500 mg Zn/kg paddy
- 1100 mg Zn/kg paddy

1.5x ↑
1.9x ↑

2.2x% ↑
RESULTS: ENGELBERG MILL STUDY

By-products

- Control
- 500 mg Zn
- 1100 mg Zn

Estimates (non-representative samples)

Combined sample

Husk

Bran

Byproducts (mixed)
## COST IMPLICATIONS FOR MILLERS

### $US DOLLARS

<table>
<thead>
<tr>
<th>Cost $US – based on 565 MT annual production</th>
<th>500 mg/kg</th>
<th>1100 mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplies / equipment</td>
<td>650</td>
<td>650</td>
</tr>
<tr>
<td>Zinc sulfate</td>
<td>6,498</td>
<td>14,145</td>
</tr>
<tr>
<td><strong>Subtotal / year</strong></td>
<td><strong>7,148</strong></td>
<td><strong>14,145</strong></td>
</tr>
<tr>
<td>Additional cost/kg milled rice $US</td>
<td>0.012</td>
<td>0.026</td>
</tr>
<tr>
<td><strong>Additional cost/kg milled rice Taka</strong></td>
<td><strong>0.9</strong></td>
<td><strong>2.0</strong></td>
</tr>
</tbody>
</table>

Within range of willingness-to-pay for ‘nutritious rice’ with health information
Up to 2.0 Tk premium
Potential Risks

- Improper handling of byproducts could create zinc contamination in the environment
- Closed management system would be required
- Husks are an important source of fuel for rice mill boilers – if burned would need to collect ash waste

Potential Opportunities

- Zinc may be extracted for use as fertilizer – a clean, reliable, local source
- If the zinc byproducts have monetary value as fertilizer, millers would be incentivized to sell
- Determine if zinc husks can be burned for fuel, and the ash recovered for use in fertilizer

ZINC IS CONCENTRATED IN BYPRODUCTS & EFFLUENT
ZINC SULFATE VALUE CHAIN

Steel production → Zinc dust recovery → Zinc sulfate → Micronutrient Fertilizer → Animal Feed
• Approximately half of arable land in Bangladesh is zinc deficient
• Use of zinc fertilizer for increased yield considered necessary by government
  • Usage of zinc fertilizer is low (~20% in 2012/13) compared to estimated need
• No local manufacture of zinc fertilizer - imported (e.g., China)
  • Product adulteration is a problem – inadequate zinc, heavy metal contamination

Increased use and quality of zinc fertilizers
Food grade zinc sulfate

Mills: Zinc fortification at soaking

Rice production – increase yield?

Zinc fortified milled rice

Extraction / use in fertilizer??

Zinc rich by-products & effluent

Consumers

Toxic

www.gainhealth.org
CONCLUSIONS

• System was considered too inefficient with too many challenges/risks to invest further

• Other strategies - zinc biofortified rice and extrusion technology continue to be invested in
  • These strategies are also challenged by rice value chain

• Prevention of zinc deficiency – need to look beyond rice as a vehicle
Salt iodization: Successfully reaching billions but suboptimal indicators

Omar Dary

USAID–Nutrition Division/HIDN/GH

USAID, Mini-University

March 4th, 2016
Consequences of iodine deficiency and excess

<table>
<thead>
<tr>
<th>Fetus</th>
<th>Abortion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stillborn</td>
</tr>
<tr>
<td></td>
<td>Congenital abnormalities</td>
</tr>
<tr>
<td></td>
<td>• Perinatal mortality</td>
</tr>
<tr>
<td></td>
<td>• Infant mortality</td>
</tr>
<tr>
<td>Neurologic cretinism:</td>
<td>Mutism, mental retardation – deafness</td>
</tr>
<tr>
<td></td>
<td>Endemic cretinism: dwarfism/ mental deficiency</td>
</tr>
<tr>
<td></td>
<td>Psychomotor impairment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Infant</th>
<th>Hypothyroidism / Irreversible mental retardation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children and adolescent</td>
<td>IQ reduced / Goiter / Hypothyroidism / Impaired physical and mental development</td>
</tr>
<tr>
<td>Adult</td>
<td>Goiter and complications Hypothyroidism</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Excesses</th>
<th>Temporal</th>
<th>Permanent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excesses</td>
<td>Hyperthyroidism (in population that were iodine deficient)</td>
<td>Thyroid Cancer (in adults from all sources of iodine)</td>
</tr>
</tbody>
</table>
# Brief history of iodized salt

<table>
<thead>
<tr>
<th>Year</th>
<th>Average [I] (mg/kg)</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1915</td>
<td>Small</td>
<td>Hunziker, in Switzerland, recommended adding small amount of iodine to the diet of small children to prevent goiter.</td>
</tr>
<tr>
<td>1917</td>
<td>-</td>
<td>Marine &amp; Kimball (Akron, Ohio, USA) reduced goiter in girls using supplements with iodine.</td>
</tr>
<tr>
<td>1921</td>
<td>1.90 – 3.75</td>
<td>The salt iodization program started in Switzerland.</td>
</tr>
<tr>
<td>1924</td>
<td>100.0 (average)</td>
<td>Michigan: Introduced, as prophylaxis against goiter, iodized salt; the country (USA) has not accepted the practice as compulsory.</td>
</tr>
<tr>
<td>1962</td>
<td>7.5</td>
<td>Iodine content is increased in Switzerland.</td>
</tr>
<tr>
<td>1980</td>
<td>15.0</td>
<td>Nodular goiter raises temporarily due to increment of iodine content.</td>
</tr>
<tr>
<td>1998</td>
<td>20.0</td>
<td>Another increment takes place based on epidemiological results.</td>
</tr>
<tr>
<td>2014</td>
<td>25.0</td>
<td>More recent increment in Switzerland to satisfy requirements for all.</td>
</tr>
<tr>
<td>Currently</td>
<td>20-60 (range)</td>
<td>Most countries, including USA; with common averages between 25 and 40 mg/kg.</td>
</tr>
</tbody>
</table>

Source: Zimmermann oral communication and *J Nutr* 2008;138:2060.
Association between goiter and urinary iodine concentration*


* The authors assumed that UIC was equivalent to 24-h UIE.
Goiter prevalence vs urinary iodine in Central America – 1965-67


* The authors estimated UIE based on UIC in causal urine samples adjusted by creatinine coefficient/ g creatinine x body weight
Goiter prevalence vs urinary iodine concentration for selecting indicator

UIE (ug I/d) estimated by multiplying the reported UIC (ug I/L) for the calculated urinary volume of each age- and gender group, based on body weight:

**Urinary volume (L/d) = 0.009 L/h.kg x 24 h/d x wt (kg)** – from IOM/ Academies of Sciences of the USA: Dietary Reference Intakes for iodine and other nutrients. National Academy Press.

Summary of the situation in Mexico - 2013. Iodine intakes through salt.

Assuming salt intakes: 7-16 g/d males, and 5-12 g/d* females, and iodine content in salt of 30 mg I/kg

Minimum average:
95 µg l/5 g salt =
19 µg l/g salt =
19 mg l/kg

* Situation in Mexico: * females, ** men

How the concept of “adequate” iodized salt originated?

<table>
<thead>
<tr>
<th>Year</th>
<th>Content [I] (mg/kg)</th>
<th>Recommendation (WHO/UNICEF/ICC-IDD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>20 (average)</td>
<td>For providing 150 µg/day in 10 g salt/day = 150 µg/g, and 30% loss (150 x 1.3 = 19.5 µg/g) at the moment of production.</td>
</tr>
<tr>
<td></td>
<td>(40) (average)</td>
<td>Nothing is mentioned for salt intake of 5 g/day, but the range of ”averages” is stated <strong>20-40 mg I/kg</strong>; a “range” was born.</td>
</tr>
<tr>
<td></td>
<td>15 (average)</td>
<td>In households.</td>
</tr>
<tr>
<td>~2000</td>
<td>15 (minimum)</td>
<td>In posterior editions, the average became “minimum” and the concept of “adequate” iodized salt was born.</td>
</tr>
<tr>
<td>2007</td>
<td>20-40 (range)</td>
<td>“the percentage of food-grade salt with iodine content of between 20 and 40 ppm in a representative sample of households must be equal or greater than 90%”</td>
</tr>
</tbody>
</table>
Iodine content in different types of salt in México-2013 (Regulation: 30 ± 10 mg/kg)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coarse salt</th>
<th>Washed salt</th>
<th>Refined salt</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>32</td>
<td>42</td>
<td>20</td>
</tr>
<tr>
<td>Median (mg/kg)</td>
<td>23.8</td>
<td>29.7</td>
<td>33.7</td>
</tr>
<tr>
<td>Mean (mg I/kg)</td>
<td>39.9</td>
<td>30.9</td>
<td>33.9</td>
</tr>
<tr>
<td>S.D. (mg I/kg)</td>
<td>46.5</td>
<td>10.0</td>
<td>2.9</td>
</tr>
<tr>
<td>C.V. (%)</td>
<td>116.4%</td>
<td>32.4 %</td>
<td>7.6 %</td>
</tr>
<tr>
<td>% samples &lt; 20 mg I/kg</td>
<td>33.4 %</td>
<td>13.8 %</td>
<td>0.0 %</td>
</tr>
<tr>
<td>% samples &lt; 15 mg I/kg</td>
<td>29.6 %</td>
<td>5.6 %</td>
<td>0.0 %</td>
</tr>
</tbody>
</table>

Situation of the iodized salt in Mexico - 2013; Regulation 30 ± 10 mg I/kg

<table>
<thead>
<tr>
<th>Content (mg/kg)</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low variation (refined salt)</td>
<td></td>
</tr>
<tr>
<td>Moderate variation (washed salt)</td>
<td></td>
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<tr>
<td>Large variation (coarse salt)</td>
<td></td>
</tr>
</tbody>
</table>
1. Nowadays, iodine is being supplied to most populations through iodized salt (discretionary—table and cooking— and salt used by food industries) or dairy products.

2. Almost all populations are receiving sufficient iodine, as the current iodine content in salt is between 25-45 mg I/kg, when only 15 mg I/kg in average would be sufficient for the current salt intakes.

3. The use of the “adequate” iodized salt (percent of samples below 15 mg I/kg) is causing confusion and it is an unfair parameter for qualifying the programmatic impact; many factors affect variation of the iodine content around the mean.

4. In general, a population median of iodine concentration in urine above 100 µg/L reflects good iodine intake in the whole population. The reference value for pregnant women is still pending.

5. Therefore, the 2 billion persons worldwide reported as at risk of suffering iodine deficiency is an exaggeration; iodized salt is one of the most successful programs of public health nutrition of the 20th Century.
Assessing program performance and potential for impact: the GAIN FACT tool

Lynnette Neufeld, PhD
Director, Monitoring, Learning and Research
Fortification has important impacts on micronutrient status and on health outcomes – but access to fortified foods and the conditions under which they are stored, purchased, and used varies greatly within and among countries.
Fortified flour is accessible (available and affordable) in communities.

Households increase purchase of fortified flour/products.

Households use fortified flour appropriately.

Micronutrient status of individuals improved.

Micronutrient status of individuals improved.

Cognition & productivity increased.

Maternal Morbidity & mortality reduced.

Child morbidity & mortality reduced.

Other interventions

Source: Flores 2013
To assess potential for impact we need to know who consumes the food, how much, and how much of the nutrient it actually contains.

**Contact coverage:** consume at least once per week

**Dietary contribution:** %

Recommended Nutrient Intakes (RNI)

**Effective coverage:** requires some point of comparison to how much is needed.

Coverage model from: Tanahashi Bull WHO 1978
The Fortification Assessment Coverage Tool
(FACT)

Coverage
- Proportion of the population that uses a fortifiable food commodity, defined appropriately for country, usually as centrally produced ("contact coverage")

Utilization
- Intake of food from modified dietary recall
  - Household
  - Women of reproductive age; children <2 yrs of age

Product quality
- Nutrient content (laboratory assessment) of fortified commodities from community or household samples

Sampling
- Large representative sample stratified by factors that might modify coverage, utilization and risk of inadequate diet
- Representative by region of residence (urban/rural), poverty, education, others
12 surveys in 10 countries:
~25,000 households representative of 1.5 billion people

<table>
<thead>
<tr>
<th>Survey</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
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<tbody>
<tr>
<td>Ghana (Pilot)</td>
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<td></td>
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<tr>
<td>Senegal (oil, wheat flour)</td>
<td></td>
<td></td>
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<tr>
<td>Rajasthan, India (oil, wheat flour, salt)</td>
<td></td>
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<tr>
<td>Abidjan, Côte d’Ivoire (oil, wheat flour)</td>
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<tr>
<td>Telangana, India (oil, wheat flour, salt)</td>
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<td></td>
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<tr>
<td>Nigeria (oil, 3 types of flour, sugar, salt)</td>
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<td></td>
</tr>
<tr>
<td>South Africa (oil, maize and wheat flour, bread, salt)</td>
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<td></td>
</tr>
<tr>
<td>Uganda (oil, maize and wheat flour, salt)</td>
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<tr>
<td>Tanzania (oil, maize and wheat flour, salt)</td>
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<td></td>
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<tr>
<td>Bangladesh (salt)</td>
<td></td>
<td></td>
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<tr>
<td>India (salt)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ghana (salt)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Senegal (salt)</td>
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</tbody>
</table>

Survey implementation period
Contact coverage of fortifiable* oil among women of reproductive age (WRA)

*Defined as commercially produced
Dietary contribution (% daily RNI) for vitamin A met from consumption of fortified oil for WRA

- Senegal
- Rajasthan, India
- Abidjan, Côte d'Ivoire

Categories:
- All
- Poor
- Non-poor
In Senegal, 51% of children 6 to 23 m of age consume fortified oil at least once per week

% RNI for vitamin A consumed from oil among children 6-23 months

Mean (18.9%)
Median (13.3%)

Consume fortifiable wheat flour at least 1/week:
• 35% in rural South
• 51% in rural North
• 61% in peri-urban areas (exl. Dakar)
• 56% in Dakar

% RNI estimated for all children who reported consuming oil at least once per week (51% of sample)
Contact coverage of fortifiable* wheat flour among WRA

*Defined as commercially produced
Dietary contribution (% daily RNI) for iron met by consumption of fortified wheat flour (WRA)

Blue lines represented expected contribution following recommended fortification levels set by WHO.
In Senegal, 57% of children 6 to 23 m of age consume fortified wheat flour at least once per week

% RNI estimated for all children who reported consuming wheat flour at least once per week (57% of sample)

Consume fortifiable wheat flour at least 1/week:
- 51% of poor
- 67% of non-poor
Contact coverage of iodized salt* by households is moderate to high in all surveys to date, but varies considerably by country.

*Reported as iodized
Utilization of salt that meets the standard* however, is highly variable by country and population group and very low in some contexts.

*Defined according to UNICEF/WHO standard of ≥ 15 ppm; except Abidjan data reported at country standard of ≥ 30 ppm.
*Preliminary results of recently completed survey. Fortifiable defined as commercially produced. Includes all those mandated for fortification in Nigeria.
Hot off the press from Uganda: Contact coverage of fortifiable foods*

*Preliminary results of recently completed survey. Fortifiable defined as commercially produced. Includes all those mandated for fortification in Uganda.
Limitations and areas of on-going work

A true measure of “effective coverage” requires an estimate of the dietary gap in micronutrient intake that we wish to address with fortification

– Our dietary intake method does not provide full dietary intake estimate – exploring options to include this in future surveys
  – E.g., Senegal – very high oil intakes are consistent with previous surveys, but whether high vit A intake from oil is of concern would depend on other sources in the diet

Our abbreviated dietary assessment estimate adapted from validated methodologies, but as yet, not validated

– Recently completed survey in South Africa included 24-hr recall on sub-set of population for comparison with our abbreviated tool

Results of these surveys contribute to evidence base, but ultimate utility depends on their utilization for program improvement

– On-going (and planned) workshops and dissemination in country to present and discuss and their implications for program
Conclusions and implications

- Substantial contribution to dietary intake of key micronutrients from fortification programs:
  - In some contexts, reaching rural, poor, children 6 to 23 mo of age, but considerable variation within and among countries
- In all countries, quality control and enforcement requires substantial improvement to identify and address under- and over-fortification

- Critical to know dietary patterns in the population to estimate potential for impact, ensure fortification levels are set appropriately and adjusted over time as dietary patterns change
- Investment in regular monitoring and surveillance and continual feedback for program improvement, including enforcement to standards is critical for impact and safety
Thank You