History of Food Fortification and Global Experience of Large Scale Food Fortification

Helena Pachón, PhD, MPH
National Summit on Fortification of Food: Enriching Food and Enriching Lives
New Delhi
16 October 2016
History of Food Fortification
Food Fortification in Ancient Times

“Legend has it that an ancient Persian physician prescribed sweet wine laced with iron filings for Jason and the Argonauts to strengthen the mythical sailors' resistance to spears and arrows during their quest for the Golden Fleece.”
Food Fortification in Modern Times

Salt Fortification with Iodine Introduced in 1920s

Natural sources of iodine are scarce and goiter was endemic.
This Presentation

Milk
[Image: www.todayifoundout.com]

Rice
[Image: www.importexportplatform.com]

Wheat flour
[Image: www.todayifoundout.com]

Oil
[Image: www.mediate.com]

Salt
[Image: thekingscrumbs.wordpress.com]
Mandatory milk fortification legislation first introduced in the 1930s
14 countries mandate milk fortification
# Nutrients added to fortified milk

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Number of countries (N=14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>12*</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>11†</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>1 (Canada)</td>
</tr>
<tr>
<td>Calcium</td>
<td>1 (China)</td>
</tr>
<tr>
<td>Folic acid</td>
<td>1 (Costa Rica)</td>
</tr>
<tr>
<td>Iron</td>
<td>1 (Costa Rica)</td>
</tr>
</tbody>
</table>

* Finland & Sweden do not add vitamin A to fortified milk
† Costa Rica, Malaysia & Thailand do not add vitamin D to fortified milk
Mandatory **oil** fortification legislation first introduced in 1965
27 countries mandate oil fortification
# Nutrients added to fortified oil

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Number of countries (N=27)</th>
<th>Range (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>27</td>
<td>6-55</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>2*</td>
<td>0.075-1.0</td>
</tr>
</tbody>
</table>

* Morocco & Mozambique add vitamin D to fortified oil

mg/kg is the same as mcg/g is the same as parts per million (ppm)
Mandatory **rice** fortification legislation first introduced in 1952

Republic Act No. 832
6 countries mandate fortification of rice

* Legislation has the effect of mandating grain fortification with at least iron or folic acid. This does not reflect how much grain is available in that country. Grain availability data from the Food and Agriculture Organization (2011). Legislation status from the Food Fortification Initiative (www.FFI network.org).
### Vitamins in rice standard (mandatory countries)

<table>
<thead>
<tr>
<th>Country</th>
<th>Thiamin (B1)</th>
<th>Niacin (B3)</th>
<th>Pyridoxine (B6)</th>
<th>Folic Acid (B9)</th>
<th>B12</th>
<th>Vitamin E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costa Rica</td>
<td>5.3</td>
<td>35</td>
<td>--</td>
<td>1.8</td>
<td>0.01</td>
<td>10.1</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>5</td>
<td>40</td>
<td>4</td>
<td>1</td>
<td>0.01</td>
<td>--</td>
</tr>
<tr>
<td>Panama</td>
<td>5</td>
<td>40</td>
<td>4</td>
<td>1</td>
<td>0.01</td>
<td>--</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>5</td>
<td>60</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Philippines</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>USA</td>
<td>4.4-8.8</td>
<td>35.2-70.4</td>
<td>--</td>
<td>1.54-3.08</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td><strong>No. countries</strong></td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>
# Minerals in rice standard (mandatory countries)

<table>
<thead>
<tr>
<th>Country</th>
<th>Iron (mg/kg)</th>
<th>Type of Iron</th>
<th>Selenium (mg/kg)</th>
<th>Zinc (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costa Rica</td>
<td>--</td>
<td>--</td>
<td>0.105</td>
<td>7.5</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>24</td>
<td>Ferric pyrophosphate</td>
<td>--</td>
<td>25</td>
</tr>
<tr>
<td>Panama</td>
<td>24</td>
<td>Ferric pyrophosphate</td>
<td>--</td>
<td>25</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>30</td>
<td>Not specified</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Philippines</td>
<td>60-90</td>
<td>Ferrous sulfate</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>USA</td>
<td>28.6-57.2</td>
<td>Not specified</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td><strong>No. countries</strong></td>
<td><strong>5</strong></td>
<td><strong>3</strong></td>
<td><strong>1</strong></td>
<td><strong>3</strong></td>
</tr>
</tbody>
</table>
Mandatory salt fortification legislation first introduced in 1949
130 countries mandate salt fortification
# Nutrients added to fortified salt

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Number of countries (N=130)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iodine</td>
<td>130</td>
</tr>
<tr>
<td>Fluoride</td>
<td>4</td>
</tr>
</tbody>
</table>

mg/kg is the same as mcg/g is the same as parts per million (ppm)

Iodine Global Network 2016
Mandatory *wheat flour* fortification legislation first introduced in 1942
85 countries mandate fortification of wheat flour

Asia: Indonesia, Nepal, Philippines, Viet Nam
**Nutrients added to fortified wheat flour**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Number of countries (N=85)</th>
<th>Range (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron*</td>
<td>84</td>
<td>16.5-140</td>
</tr>
<tr>
<td>Folic acid</td>
<td>80</td>
<td>1-6.0</td>
</tr>
<tr>
<td>Thiamin (vitamin B1)</td>
<td>66</td>
<td>1.5-15</td>
</tr>
<tr>
<td>Riboflavin (vitamin B2)</td>
<td>64</td>
<td>1.3-9.6</td>
</tr>
<tr>
<td>Niacin (vitamin B3)</td>
<td>63</td>
<td>13-90</td>
</tr>
<tr>
<td>Zinc</td>
<td>30</td>
<td>15-116</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>24</td>
<td>0.0005-0.04</td>
</tr>
<tr>
<td>Vitamin B6</td>
<td>19</td>
<td>2.5-10.0</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>13</td>
<td>0.5-3.0</td>
</tr>
<tr>
<td>Calcium</td>
<td>5</td>
<td>1100-3900</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>4</td>
<td>0.01-0.015</td>
</tr>
</tbody>
</table>

* Iron compounds added include electrolytic, ferrous fumarate, ferrous sulfate, NaFeEDTA, reduced mg/kg is the same as mcg/g is the same as parts per million (ppm)
Summary (1)

• Mandatory food fortification has been successfully practiced for decades

• Currently, many countries mandate fortification of
  – Milk: 14
  – Oil: 27
  – Rice: 6
  – Salt: 130
  – Wheat flour: 85
Many nutrients are added to mandatorily fortified:

- Milk: 2 minerals, 4 vitamins
- Oil: 2 vitamins
- Rice: 3 minerals, 6 vitamins
- Salt: 2 minerals
- Wheat flour: 3 minerals, 8 vitamins
Global Experience
Health Improvements Observed from Large-Scale Food Fortification:
Wheat Flour as an Example
Neural tube defects and folic acid

Birth defect affecting the brain and spinal cord

- Occurrence of neural tube defects (NTDs) yearly
  - 324,000 global
  - 118,000 India
- ~75% are preventable if the mother has enough folic acid around conception

March of Dimes 2006; Youngblood 2013
Reductions in neural tube defects (NTDs) after flour fortification with folic acid was initiated

Folic acid in flour ranged from 1.2-2.2 mg/kg
Other health improvements attributable to fortified wheat flour

<table>
<thead>
<tr>
<th>Nutrients in Flour</th>
<th>Outcome</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Folic acid</td>
<td>Reduces folate deficiency</td>
<td>Colapinto 2011 Odewole 2013</td>
</tr>
<tr>
<td>Folic acid</td>
<td>Reduces folate-deficiency anemia</td>
<td>Odewole 2013</td>
</tr>
<tr>
<td>Iron</td>
<td>Reduces iron deficiency</td>
<td>Pachón 2015</td>
</tr>
<tr>
<td>Iron &amp; other nutrients</td>
<td>Reduces anemia*</td>
<td>Pachón 2015</td>
</tr>
</tbody>
</table>

* When WHO recommendations for flour fortification with iron are followed
Summary

• Evidence from large-scale implementation

• Flour fortification with folic acid reduces
  – Neural tube defects
  – Folate deficiency
  – Folate-deficiency anemia

• Flour fortification with iron reduces
  – Iron deficiency

• Flour fortification with multiple nutrients reduces
  – Anemia if WHO recommendations are followed
Lessons Learned with Large Scale Food Fortification
Mandatory fortification is more effective than voluntary fortification

Fortification with folic acid increases serum folate

- Voluntary fortification began in 1995 in Australia
- Mandatory wheat flour fortification began in September 2009
- Analysis of 20,592 blood samples

Ross 2011
Mandatory fortification is more effective than voluntary fortification

Fortification with folic acid reduces NTDs

- Voluntary fortification
- Mandatory fortification

NTDs per 10,000 conceptions that resulted in a birth
Lesson learned (1)

Mandatory fortification is more effective than voluntary fortification for improving health outcomes
Fortification is most feasible & sustainable in a modern milling industry

- Fortifying at small mills is *technically* feasible but challenging to *sustainably implement*
  - Small mills require consistent personnel training and often financial support (for equipment and premix)
  - Large numbers of mills require high government capacity to monitor and regulate

http://www.pdi-global.org/Site/how2donate.asp

http://www.satakeindia.com/
Fortification is most feasible & sustainable in a modern milling industry

<table>
<thead>
<tr>
<th></th>
<th>Costa Rica</th>
<th>Philippines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory rice fortification</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Rice milling companies (number)</td>
<td>11</td>
<td>~11,000</td>
</tr>
<tr>
<td>National rice supply fortified (%)</td>
<td>100%</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>

“(Costa Rica) MOH was able to demonstrate its authority to enforce the legislation...”

“Limited government budgets to monitor thousands of milling companies...”

Forsman 2014

FFI 2016
Lesson learned (2)

Fortification is most feasibly & sustainably implemented through a modern, centralized milling industry
Government monitoring is essential in fortification

A monitoring and evaluation system for food fortification programmes

- **Food**: National or imported

- **Vitamins premix**: Certificate of Quality (Food Control and Customs)

  - **Imported fortified food**: Certificate of Conformity or Inspection (Corroborating trial) (Food Control Dept. and Customs)
  - **Internal monitoring** (factories or packers)
    - Importation warehouse
  - **External monitoring** (factories or packers)
  - **Commercial monitoring** (at retail stores)
    - Quality auditing with Conformity Assessment (Food Control/witnesses)

  - **REGULATORY MONITORING**
    - Quality Control and Quality Assurance (Dept. of Quality Control of Factories and Packers)
    - Factory Inspection (Corroborating trial) Technical Auditing (Government Food Control Unit)
    - Verification of Legal Compliance (Corroborating trial in retail stores) (Food Control and Units of Standards and/or Consumer Protection)

  - **HOUSEHOLD/INDIVIDUAL Monitoring and evaluation**
    - Household/individual monitoring
    - Impact evaluation (individuals, households)
    - Assessment of provision, utilization and coverage
    - Assessment of impact on consumption, biochemicals, clinical and functional outcome

Government monitoring activities
Concern that lack of monitoring & enforcement leads to low compliance

Percentage of Vitamin A Compliance in Oils

- 11.6% Above range (>20,000 IU)
- 12.6% Within range (20,000-14,000 IU)
- 32.6% Below range (0.1-13,999 IU)
- 43.2% Not detectable

75.8% Not Compliant

Ogunmoyela 2014
Government monitoring and enforcement can enhance fortification compliance by producers and importers.
Flour fortification is associated with a decreased anemia prevalence in non-pregnant women.

Each year of flour fortification was associated with a 2.4% decreased anemia prevalence. Among non-fortification countries, no reduction in anemia prevalence was observed over time.

Analysis controlled for Human Development Index and malaria.

Barkley 2015
Most fortification countries followed WHO recommendations

### Use WHO-recommended Iron Compounds

<table>
<thead>
<tr>
<th>Yes (n=11)</th>
<th>No (n=1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolivia</td>
<td>Indonesia</td>
</tr>
<tr>
<td>Costa Rica (wheat*)</td>
<td></td>
</tr>
<tr>
<td>Fiji</td>
<td></td>
</tr>
<tr>
<td>Honduras</td>
<td></td>
</tr>
<tr>
<td>Jordan</td>
<td></td>
</tr>
<tr>
<td>Mexico (maize*)</td>
<td></td>
</tr>
<tr>
<td>Nicaragua</td>
<td></td>
</tr>
<tr>
<td>Peru</td>
<td></td>
</tr>
<tr>
<td>Philippines</td>
<td></td>
</tr>
<tr>
<td>Senegal</td>
<td></td>
</tr>
<tr>
<td>Uzbekistan</td>
<td></td>
</tr>
</tbody>
</table>

*predominant grain in country

---

Low-extraction flour: NaFeEDTA, ferrous sulfate, ferrous fumarate, electrolytic iron

High-extraction flour: NaFeEDTA

---

WHO 2009, Barkley 2015, Hurrell 2015
Lesson learned (4)

In setting fortification standards, all countries should aim to follow WHO recommendations for flour fortification.
Household use of adequately iodized salt fell after supplies of potassium iodate ended in Viet Nam

Ref: National IDD Surveys and Multiple Cluster Indicator Survey in 2011

End of free KIO3

KIO3 – potassium iodate
Lesson learned (5)

For long-term sustainability of fortification, it is not necessary or useful to provide free vitamin and mineral premix
Processed foods are the main sources of sodium in industrialized countries

Only half of countries with mandatory salt iodization specify that salt used in processed foods should be iodized

*Slide courtesy Roland Kupka*
Lesson learned (6)

Important to periodically monitor food consumption patterns, so that the food fortification program can be adjusted as needed.
Summary (1)

• Global experience has provided a number of lessons for successful implementation of fortification
  – Mandatory fortification is more effective than voluntary fortification for improving health outcomes
  – Fortification is most feasibly & sustainably implemented through a modern, centralized milling industry
  – Government monitoring and enforcement can enhance fortification compliance by producers and importers
Summary (2)

- Global experience has provided a number of lessons for successful implementation of fortification
  - In setting fortification standards, all countries should aim to follow WHO recommendations for flour fortification
  - For long-term sustainability of fortification, it is not necessary or useful to provide free vitamin and mineral premix
  - Important to periodically monitor food consumption patterns, so that the food fortification program can be adjusted as needed
Conclusions

• Mandatory food fortification has been successfully practiced for decades throughout the globe
• Currently, many countries mandate food fortification
• Food fortification improves public health outcomes
• Global experience has provided a number of lessons for successful implementation of fortification
Acknowledgements

- Rita Bhatia
- Karen Codling
- Subrata Dutta
- Jonathan Gorstein
- Daniel López de Romaña
- Corey Luthringer
- Venkatesh Mannar
- Scott Montgomery
- Chandrakant Pandav
- Becky Tsang
- Sarah Zimmerman
For more information:

www.FFInetwork.org
www.Facebook.com/FFInetwork
https://twitter.com/FFINetwork

Join the Food Fortification Initiative group on [Linked In](#)

Contact:
Helena.Pachon@emory.edu

SMARTER  STRONGER  HEALTHIER