Overview

1. Status of grain fortification
   1. Mandatory fortification
   2. Rice fortification activities
2. Evidence for rice fortification
   1. Nutrient retention across supply chain
   2. Organoleptic/sensory
   3. Biological impact (efficacy/effectiveness)
3. Lessons learned in grain fortification
4. Role of the private sector
5. Key messages
Which countries have mandatory laws to fortify?
87 countries with mandatory flour or rice fortification*

*With at least iron or folic acid
Wheat flour: 86 countries*
*With iron or folic acid

Global Fortification Data Exchange
http://FortificationData.org
Maize flour: 16 countries*

*With iron or folic acid
Rice: 6 countries*

*With iron or folic acid

- United States
- Costa Rica
- Panama
- Nicaragua
- Papua New Guinea
- Philippines
Rice: 6 countries*
*With iron or folic acid

- **United States** — allows dusting technology if label warns against washing
- **Costa Rica** — requires > 80% nutrient retention after washing
- **Panama** — requires > 80% nutrient retention after washing
- **Nicaragua** — requires > 80% nutrient retention after washing
- **Papua New Guinea** — no retention language
- **Philippines** — no retention language
Global status of rice fortification programs

USA
Nicaragua
Costa Rica
Panama
Colombia
Ecuador
Peru
Brazil
Mali
Liberia
Benin
Rep. of Congo
Kantaka, Gujarat, Tamil Nadu
India: Odisha,
Voluntary standards (3)

Voluntary standards (3)

Mandatory legislation (6)

Market-based activities (5)

Workplace benefit program (2)

Research study (2)

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Workplace benefit program (2)

Research study (2)
Social Safety Net Programs

- School feeding programs
- Food distribution to targeted populations
- Food aid
- Related: workplace benefit programs
- Where in Latin America: Nicaragua
Voluntary Standards and Market-Based Activities

- Not required by law
- 3 countries have voluntary standards (India, Bangladesh, Venezuela)
- Several countries in Latin America have voluntarily fortified rice available in the marketplace: Colombia, Ecuador, Peru, Brazil
- Typically a premium product targeted at higher-income consumers buying branded product
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Evidence for rice fortification

- Retention or Stability: during normal storage, distribution, and processing of fortified food

Wirakartakusumah 1998; USAID no date
Evidence for rice fortification

Sensory = Organoleptic

Good Fortification = no changes!
Evidence for rice fortification

Biological Impact (efficacy and effectiveness)*

- Improved immune system
- Reduced number of serious birth defects
- Better cognitive performance

*usually measured as nutrient levels in the blood

Food for the Poor, Nicaragua
Research criteria

• Used ferric pyrophosphate as the iron compound (other compounds cause dark coloring to the fortified kernel)

• Focused on hot extrusion or coating technology
  • Cold extrusion now generally considered less acceptable from a sensory standpoint
  • Dusting is known to not retain nutrients when washed

• Sensory research: consumer panels
# Nutrient retention after storage

Fortified rice produced through extrusion

<table>
<thead>
<tr>
<th>Study</th>
<th>Iron (FPP) %</th>
<th>Zinc %</th>
<th>Vitamin A %</th>
<th>Thiamin (B1) %</th>
<th>Niacin (B3) %</th>
<th>Folic Acid (B9), %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kuong 2016</td>
<td>89.4</td>
<td>96.3</td>
<td>51.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(40C, 75% humidity)</td>
<td>(180 days)</td>
<td>(180 days)</td>
<td>(180 days)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lee 2000</td>
<td></td>
<td></td>
<td>47.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(35C, 80% humidity)</td>
<td></td>
<td></td>
<td>(168 days)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Li 2008a</td>
<td></td>
<td></td>
<td>52.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(40C, 100% humidity)</td>
<td></td>
<td></td>
<td>(140 days)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Li 2008b</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td>(40C, 60% humidity)</td>
<td>(224 days)</td>
<td>(224 days)</td>
<td>(224 days)</td>
<td>(224 days)</td>
<td>(224 days)</td>
<td></td>
</tr>
<tr>
<td>Li 2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>57-75</td>
</tr>
<tr>
<td>(40C, 60% humidity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(270 days)</td>
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<tr>
<td>Murphy 1992</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(45C, 75% humidity)</td>
<td></td>
<td></td>
<td>(182 days)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Pinkaew 2012</td>
<td></td>
<td></td>
<td>54-93</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(30C, 76% humidity)</td>
<td></td>
<td></td>
<td>(126 days)</td>
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</tr>
</tbody>
</table>

Highest retention: iron and zinc; Intermediate retention: B vitamins; Most sensitive: vitamin A

FPP, ferric pyrophosphate
Nutrient retention after storage
Fortified rice produced through coating

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<thead>
<tr>
<th>Study</th>
<th>Iron (FPP) %</th>
<th>Zinc %</th>
<th>Vitamin A %</th>
<th>Thiamin (B1) %</th>
<th>Niacin (B3) %</th>
<th>Folic Acid (B9), %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kuong 2016 (40C, 75% humidity)</td>
<td>91.1 (180 days)</td>
<td>96.8 (180 days)</td>
<td>6.9 (180 days)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Highest retention: iron and zinc; Lowest retention: vitamin A

FPP, ferric pyrophosphate
**Nutrient retention after cooking**

**Fortified rice produced through extrusion**

<table>
<thead>
<tr>
<th>Study</th>
<th>Iron, %</th>
<th>Zinc, %</th>
<th>Vitamin A, %</th>
<th>Thiamin (B1), %</th>
<th>Folic acid (B9), %</th>
<th>Vitamin B12, %</th>
<th>Vitamin C, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Murphy 1992</td>
<td>60</td>
<td>96</td>
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<tr>
<td>Lee 2000</td>
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</tr>
<tr>
<td><strong>Excess water</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hof 2007</td>
<td>-</td>
<td>62</td>
<td>32-47</td>
<td>48</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Pinkaew 2012</td>
<td></td>
<td></td>
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<tr>
<td>Silveira 2016</td>
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<td></td>
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</tr>
<tr>
<td>Wieringa 2014</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Excess water</strong></td>
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<td></td>
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<tr>
<td>Hackl 2017</td>
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<tr>
<td><strong>Excess water</strong></td>
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*All studies used “absorption” cooking method, some also used “excess water” cooking method*

**Absorption** – all water absorbed into rice (e.g. 2:1 or 3:1 water:rice ratio)

**Excess water** – more water used than necessary; excess water poured out after rice is cooked (e.g. 6:1 water:rice ratio)
**Nutrient retention after cooking**

**Fortified rice produced through extrusion**

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<td></td>
<td>60, 96</td>
<td></td>
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</tr>
<tr>
<td>Lee 2000</td>
<td></td>
<td></td>
<td></td>
<td>75-87</td>
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</tr>
<tr>
<td><em>Excess water</em></td>
<td></td>
<td></td>
<td></td>
<td>77</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Hof 2007</td>
<td>-</td>
<td>62</td>
<td>32-47</td>
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<td></td>
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<tr>
<td>Pinkaew 2012</td>
<td></td>
<td></td>
<td>90.2</td>
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<td></td>
</tr>
<tr>
<td>Silveira 2016</td>
<td></td>
<td></td>
<td></td>
<td>50-65</td>
<td>75-96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wieringa 2014</td>
<td>46, 88</td>
<td>29, 90</td>
<td>14, 62</td>
<td>15, 117</td>
<td>19, 130</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Excess water</em></td>
<td>58, 86</td>
<td>73, 93</td>
<td>2, 4</td>
<td>41, 86</td>
<td>74, 95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hackl 2017</td>
<td>102</td>
<td>95</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Excess water</em></td>
<td>87.5</td>
<td>63.7</td>
<td></td>
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<td></td>
</tr>
</tbody>
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*All studies used “absorption” cooking method, some also used “excess water” cooking method.

Absorption – all water absorbed into rice (e.g. 2:1 or 3:1 water:rice ratio)

Excess water – more water used than necessary; excess water poured out after rice is cooked (e.g. 6:1 water:rice ratio)

Large variability in nutrient retention between different manufacturers using the same technology (e.g. Murphy, Wieringa).

For vitamins, “excess water” compared to “absorption” cooking method resulted in lower retention in extruded fortified rice.
## Nutrient retention after cooking*

**Fortified rice produced through coating**

<table>
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<th>Iron, %</th>
<th>Zinc, %</th>
<th>Vitamin A, %</th>
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<th>Niacin (B3), %</th>
<th>Folic acid (B9), %</th>
<th>Vitamin B12, %</th>
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<tbody>
<tr>
<td>Peil 1981</td>
<td>-</td>
<td>-</td>
<td>70</td>
<td>18</td>
<td>18</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wieringa 2014</td>
<td>88, 93</td>
<td>87, 94</td>
<td>55, 58</td>
<td>111, 147</td>
<td></td>
<td>48, 99</td>
<td></td>
</tr>
<tr>
<td><em>Excess water</em></td>
<td>87, 126</td>
<td>85, 109</td>
<td>0, 5</td>
<td>76, 90</td>
<td></td>
<td>40, 129</td>
<td></td>
</tr>
<tr>
<td>Hackl 2017</td>
<td>100</td>
<td>83</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Excess water</em></td>
<td>47</td>
<td>59</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Losso 2017</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Excess water</em></td>
<td>50-67</td>
<td></td>
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<td></td>
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**Absorption** – all water absorbed into rice (e.g. 2:1 or 3:1 water:rice ratio)

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More recent studies showed greater retention (Wieringa, Hackl, Losso) than older study (Peil)
Retention/Stability summary:

• Depends on many factors: heat, humidity, packaging, nutrients included in the rice, cooking method, the rice fortification technology, the quality of the fortified kernel production process

• Minerals (iron, zinc) have better stability than vitamins but studies indicate both can be retained at adequate levels

• Assumption: if biological impact studies show improvement, nutrients were retained
### Sensory quality

#### Fortified rice produced through extrusion and coating

<table>
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<tr>
<th>Study</th>
<th>Sensory evaluation outcome(s)</th>
</tr>
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<tbody>
<tr>
<td>Shrestha 2003 (coated, folic acid)</td>
<td>No difference between fortified and unfortified rice</td>
</tr>
<tr>
<td>Moretti 2005 (extruded, iron)</td>
<td>Tested multiple kinds of micronized iron compounds. No difference between fortified and unfortified rice</td>
</tr>
<tr>
<td>Beinner 2010 (extruded, iron)</td>
<td>No difference between fortified and unfortified rice</td>
</tr>
<tr>
<td>Radhika 2011 (extruded, iron)</td>
<td>No difference between fortified and unfortified rice</td>
</tr>
<tr>
<td>Van 2014 (extruded, multivitamin)</td>
<td>Able to identify fortified rice but were neutral or favored fortified rice more than unfortified rice</td>
</tr>
<tr>
<td>Hussain 2014 (extruded, multivitamin)</td>
<td>Able to identify fortified rice but had similar preference for fortified and unfortified rice</td>
</tr>
<tr>
<td>de Pee 2016 (coated, extruded, multivitamin)</td>
<td>Children: No difference between fortified and unfortified rice / Women: Preferred the coated rice; liked extruded rice the same as unfortified rice</td>
</tr>
</tbody>
</table>

Sensory/Organooleptic summary:

• Studies asking participants to eat fortified and non-fortified rice and compare differences:
  • Participants (woman and children): In most cases could not tell the difference between fortified and unfortified rice
  • In cases where they detected the fortified rice, they rated it favorably compared with unfortified rice
GUIDELINE:
FORTIFICATION OF
RICE WITH VITAMINS
AND MINERALS
AS A PUBLIC
HEALTH STRATEGY

World Health Organization
“...the provision of rice fortified with vitamins and minerals including iron, when compared with unfortified rice, probably improves iron status by reducing the risk of iron deficiency by 35%”

“When the fortification of rice includes vitamin A, it may reduce both iron deficiency and vitamin A deficiency.”

“When fortification includes folic acid, fortified rice may slightly increase serum folate concentrations."
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Lessons learned in fortification

• Recognize limitations – mandatory fortification is a blunt tool, less able to target populations

• Feasibility and compliance are linked – much easier to regulate ~10 rice mills (Costa Rica) compared to ~10,000 mills (Philippines)

• Voluntary fortification and mandatory fortification have different goals
  • Voluntary fortification: added-value premium product for higher income consumers
  • Mandatory fortification: improve nutrition in the general population
Private sector role in mandatory fortification

• Fortification champions: rice is not just carbohydrates – it can improve health outcomes
• Resource to identify opportunities and gaps – you know your industry best
• Active participant in discussions to develop legislation and regulations – the private sector implements rice fortification
Key messages (1)

1. Rice fortification is less practiced on a global scale but activities are increasing

2. Retention and stability studies difficult to compare, but generally retention follows: iron, zinc > B vitamins > vitamin A

3. Sensory studies have shown generally good acceptability
Key messages (2)

3. Voluntary fortification does not reach the masses, but mandatory can have broad coverage.

4. Industrially milled rice will be easier to fortify (and regulate) than rice milled in small-mills.

5. We need more private sector champions in fortification!
For more information:

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

Join the Food Fortification Initiative group on [Linked In](https://www.linkedin.com)

Contact:
- Helena.Pachon@emory.edu
- Becky.Tsang@FFInetwork.org

Food Fortification Initiative
Enhancing Grains for Healthier Lives