Technology for Rice Fortification

Finding practical solutions

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# Three most consumed grains

Globally available for human consumption in 2011:¹

<table>
<thead>
<tr>
<th></th>
<th>Million tons of wheat</th>
<th>Million tons of rice</th>
<th>Million tons of maize</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>450</td>
<td>371</td>
<td>122</td>
</tr>
</tbody>
</table>

- Wheat flour fortification
  - 80 countries with mandatory flour fortification²
  - 31% of world’s wheat flour is fortified²
  - Continue focused efforts on wheat and expand to maize

- Rice opportunity
  - Bring rice fortification to scale

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¹ Food Balance Sheet World Total for 2011, the latest year with data. Food and Agriculture Organization of the United Nations
http://faostat3.fao.org/faostat-gateway/go/to/browse/FB/CC/E

² Food Fortification Initiative database, August 2014
Rice availability and fortification legislation

| 75 or more grams available per person per day | Mandatory fortification legislation * 5 countries |
| Less than 75 grams available per person per day | No availability or legislation data |

* Legislation has effect of mandating grain fortification with at least iron or folic acid; does not reflect how much grain is available.
Grain availability data from the Food and Agriculture Organization (2009).
Legislation status from the Food Fortification Initiative (www.FFInetwork.org) June 2014
Several requirements for successful rice fortification

- **Storage**: Stability during storage
- **Preparation**: Limited losses during preparation: washing, cooking, discarding excess water
- **Acceptability**: Acceptability to consumer: appearance (shape and colour), taste
- **Absorption**: Availability for absorption by the body

**Impact by**: choice of fortificant forms, choice of fortificant mixture, fortification technology

**Effectiveness**
What about rice flour?

- Similar to wheat flour or maize flour fortification
- Simple addition of fortification mix to milled and ground rice
- Used for noodles, buns and dumplings
- Relatively small consumption compared to rice grains

Potential challenge:

- Phytate content impacts iron and potentially zinc bioavailability; this can be managed
Technological challenges for fortifying rice grains

- Rice is commonly consumed as whole grains; fortifying grains is more complicated than fortifying flour (not a fine powder mixed with fine powder)
- Rice is usually washed before cooking
- Different cooking procedures
  - soaking
  - various amounts of water
  - various cooking times
Available technologies

- Parboiling
- Dusting
- Coating
- Extrusion
  - Cold
  - Warm
  - Hot

Saman Rice Mill in Uruguay. Photo by Angela Rowell.
Parboiling – indirect fortification

• Treating with hot water and/or steam enhances intrinsic nutrients

• Additional nutrients not usually included

• Efforts to get external nutrients into the grain (iron, zinc, folic acid) have been studied

DSM research and C. Prom-u-thai, 2011
Dusting

- All rice grains dusted with a fortificant mix
- Limited nutrient protection
- Sedimentation risk
- Frequently done in USA
- Due to nutrient loss, not suitable in countries where rice is washed or where excess cooking water is discarded
Dusted rice with warning and cooking instructions

Cooking Directions - On the Stove
Bring 2 cups of water to a boil in a 2-quart heavy saucepan. Add margarine and salt, if desired. Stir in 1-cup rice. Cover, reduce heat and simmer for 20 minutes or until all water is absorbed.
Overview: creating fortified kernels to blend with non-fortified rice grains

Applies to coating and extrusion

Chart adapted from Steiger 2012
How to blend fortified kernels

Continuous mixing

Fortified rice kernels

Natural rice

Feeder MSDF

Mixing

Fortified Rice

Packaging or storage

Batch mixing

Fortified rice kernels

Natural rice

Weigh

High-speed mixer AHML

Fortified Rice

Packaging or storage

Bühler diagrams and photos
Key considerations

• Seek scientific evidence of nutritional effectiveness in light of rice preparation and utilization.
• Ensure that fortified kernels closely resemble non-fortified rice in size, shape, color, and density in both dry and cooked state. They should be indistinguishable to the average consumer.
• Require no changes in traditional rice preparation or cooking.
• Choose a cost-effective option.
Challenge of homogeneity

• Fortified kernels must match non-fortified rice in shape, size and color

Rice varieties for sale at a shop in Viet Nam. Photo by Brian Waldron.

http://www.riceauthority.com/rice-varieties/
Rice conformity

Bangladesh woman preparing rice. World Fish photo.

NutriRice from Bühler Group.
Coating

• Nutrients are added in coating layer on the rice surface
  • Several coating technologies; different performance of FK
  • Some rinse-resistant; some not
• Native rice variety can be coated
• Either broken or whole grains can be coated
• Nutrients disperse in rice upon cooking; allows higher concentration of nutrients in FK

Examples of fortified rice made by blending coated kernels with non-fortified rice. Wright Group photo.
Extrusion

1. Broken rice grains can be used as starting material
2. Micronutrients are equally distributed inside the fortified kernel
3. Only few particles are on the surface, thus reducing exposure to environment and nutrient degradation
4. Color impact from micronutrients depends on nutrient formulation
Extrusion technologies

Temperature influences appearance and cooking characteristics of final fortified kernels

- Cold extrusion uses a pasta press at 30 – 50°C
- Warm extrusion includes a preconditioner and uses a pasta press or extruder (single or double) at 60 – 80°C
- Hot extrusion includes a preconditioner and uses a extruder (single or double) at 80 – 110°C
Basic extrusion steps

1. **Rice flour** → **Premix** → **Additives** → **Dry mixing**
2. **Water Steam** → **Conditioning**
3. **Water Steam** → **Dough formation**
4. **Shaping**
5. **Stabilising**
6. **Drying** → **Fortified Rice Kernels**

**Additional Diagram:****
- **Raw Materials** → **Milling** (粉碎)**
- **Ingredients** → **Pre-conditioning** (预调质)**
- **Extruder** (挤压机)

*DSM research*
Appearance of fortified kernels

From: Steiger et al. Fortification of rice: technologies & nutrients. NY Anals 2014
Which MN to add to rice?

As for maize and wheat flours:
- Iron
- Folic Acid
- Vitamin B12
- Vitamin A
- Zinc

Many others also possible, such as:
- Vitamin E
- Vitamin D
- Selenium
- Lysine

For rice, also add MN lost through polishing:
- Thiamin
- Vitamin B6
- Niacin

Commonly added in large scale programs:

Possible, but:
- Riboflavin
- Beta-carotene
- Calcium
- Vitamin C
- DHA
- Iodine

De Pee S. Annals NY Acad Sci 2014
Iron compounds with >80% bioavailability

<table>
<thead>
<tr>
<th>Iron compound</th>
<th>Relative bioavailability (^A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferrous sulfate (7H(_2)O)</td>
<td>100</td>
</tr>
<tr>
<td>Ferrous sulfate, dried</td>
<td>100</td>
</tr>
<tr>
<td>Ferrous gluconate</td>
<td>89</td>
</tr>
<tr>
<td>Ferrous bisglycinate</td>
<td>&gt;100 (^B)</td>
</tr>
<tr>
<td>Sodium iron EDTA</td>
<td>&gt;100 (^B)</td>
</tr>
<tr>
<td>Ferrous fumarate</td>
<td>100</td>
</tr>
<tr>
<td>Ferrous succinate</td>
<td>92</td>
</tr>
</tbody>
</table>

\(^A\) Relative to hydrated ferrous sulfate (FeSO4.7H2O), in adult humans
\(^B\) Absorption is two-three times better than that from ferrous sulfate if the phytate content of food vehicle is high

Guidelines on Food Fortification with Micronutrients, World Health Organization, 2006
Color impact by iron type

Bühler photo.
Iron commonly used in rice fortification

<table>
<thead>
<tr>
<th>Iron compound</th>
<th>Relative bioavailability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferric orthophosphate</td>
<td>25-32</td>
</tr>
<tr>
<td>Ferric pyrophosphate</td>
<td>21-74</td>
</tr>
</tbody>
</table>

Guidelines on Food Fortification with Micronutrients, World Health Organization, 2006
Other minerals

<table>
<thead>
<tr>
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<th>Compounds Used</th>
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<tbody>
<tr>
<td>Zinc</td>
<td>Zinc Oxide (Zinc sulfate)</td>
</tr>
<tr>
<td>Selenium</td>
<td>Sodium selenite</td>
</tr>
<tr>
<td>Calcium</td>
<td>Calcium carbonate</td>
</tr>
</tbody>
</table>

DSM research
## Vitamins

<table>
<thead>
<tr>
<th>Water Soluble</th>
<th>Compound used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin B1</td>
<td>Thiamine mononitrate</td>
</tr>
<tr>
<td>Vitamin B6</td>
<td>Pyridoxine hydrochloride</td>
</tr>
<tr>
<td>Vitamin B9</td>
<td>Folic acid</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>B12 1% sd</td>
</tr>
<tr>
<td>Vitamin B3 (niacin)</td>
<td>Niacinamide</td>
</tr>
<tr>
<td>Vitamin B2</td>
<td></td>
</tr>
</tbody>
</table>

### Fat Soluble

<table>
<thead>
<tr>
<th>Vitamin A</th>
<th>A palmitate stabilized with BHT</th>
</tr>
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<tbody>
<tr>
<td>Vitamin D</td>
<td>Vitamin D stabilized</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>Tocopherol acetate</td>
</tr>
</tbody>
</table>

### Other

<table>
<thead>
<tr>
<th>Beta Carotene</th>
<th>BC 10%WS</th>
</tr>
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<tbody>
<tr>
<td>Vitamin C</td>
<td>Sodium ascorbate /Ascorbic acid</td>
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</table>
Nutrient retention

Study examined retention of 5 nutrients in fortified rice made via hot extrusion, cold extrusion, and coating, with five different preparation and cooking methods.

• Similar retention for all fortification technologies
• Overall retention of iron, zinc, vitamin B12 and folic acid was between 75-100%
• Vitamin A retention significantly affected
Conclusion

- Though rice is the world’s second most commonly consumed cereal grain, it is rarely fortified.
- Dusting is not an appropriate rice fortification technology where rice is washed/cooked excess water.
- Coating and extrusion are viable rice fortification technologies.
- Clear requirements for fortified rice (sensory, performance and nutrient level) need to be set and fortified kernel suppliers vetted.
- The technology used and nutrients included must yield fortified rice that is acceptable to the target population and meets vitamin and mineral specifications.
Thank you
Terima kasih
Salamat Po

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