Technology for Rice Fortification

Finding practical solutions

Scott J. Montgomery
Director, Food Fortification Initiative (FFI)
sjmontgom@gmail.com

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PATH World Food Programme Micronutrient Initiative unicef gain

Three most consumed grains

Globally available for human consumption in 2011:[1]

450	371	122
Million tons of wheat	Million tons of rice	Million tons of maize

- Wheat flour fortification
  - 80 countries with mandatory flour fortification[2]
  - 31% of world's wheat flour is fortified[2]
  - Continue focused efforts on wheat and expand to maize
- Rice opportunity
  - Bring rice fortification to scale

[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

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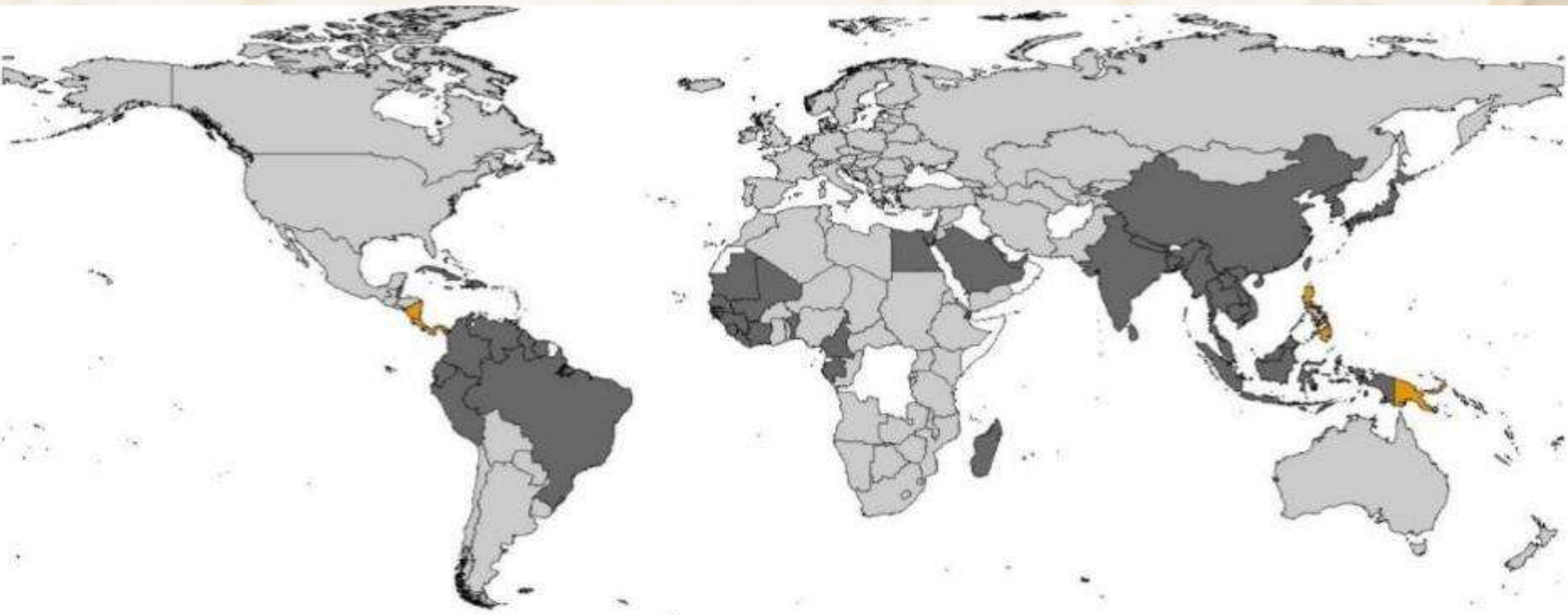
Rice availability and fortification legislation



(dark grey)	75 or more grams available per person per day
(light grey)	Less than 75 grams available per person per day
(orange)	Mandatory fortification legislation * 5 countries
(white)	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

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Several requirements for successful rice fortification

Storage → Preparation → Acceptability → Absorption

Impacted by: choice of fortificant forms, choice of fortificant mixture, fortification technology

Stability during storage

Limited losses during preparation: washing, cooking, discarding excess water

Acceptability to consumer: appearance (shape and colour), taste

Availability for absorption by the body

Efficacy

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.

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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

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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

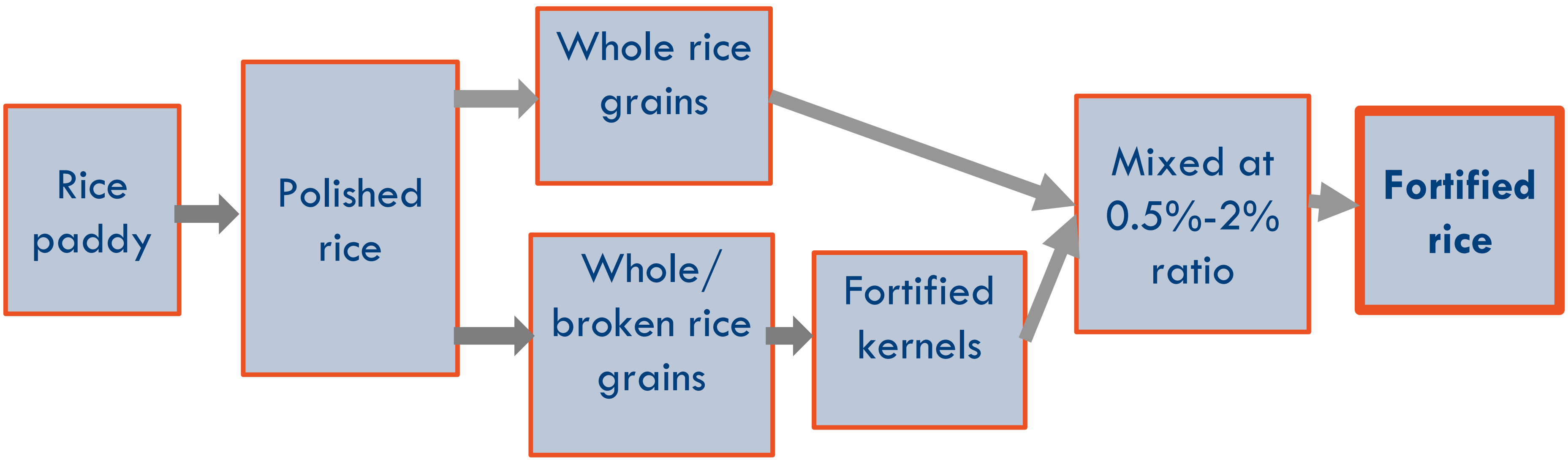

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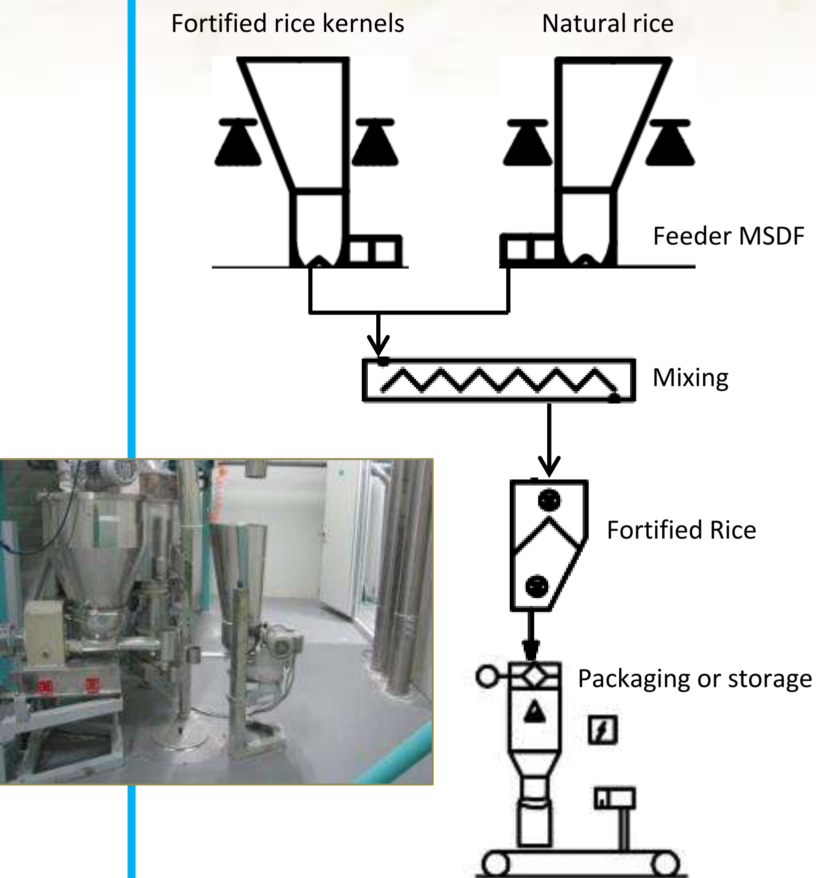
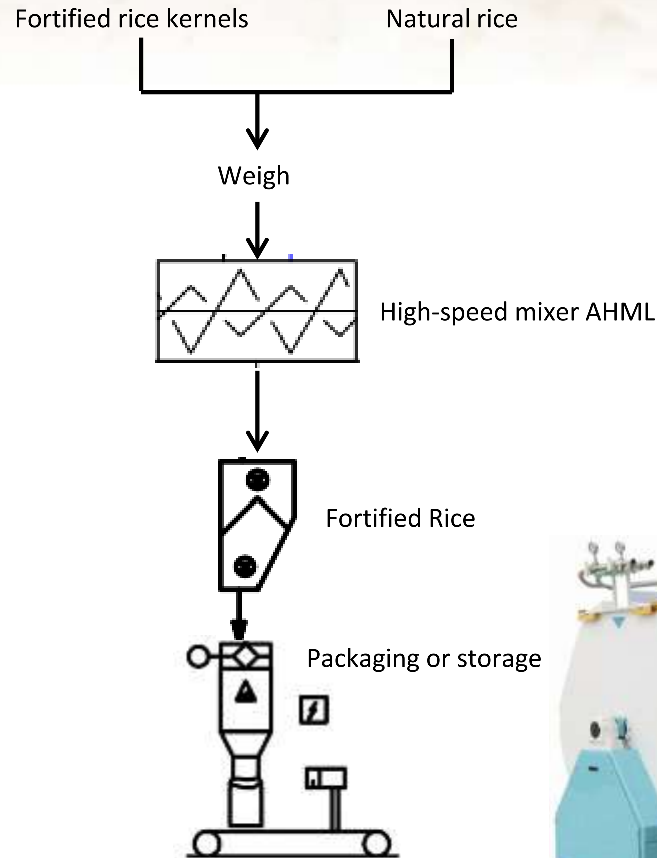
Chart adapted from Steiger 2012

How to blend fortified kernels

Continuous mixing



Batch mixing



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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.

United States Department of Agriculture commodity requirements for milled rice and fortified milled rice for use in international food assistance programs.

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/

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Rice conformity

Bangladesh woman preparing rice. World Fish photo.

NutriRice from Bühler Group.

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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.

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DSM and Wright Group research

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

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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

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Photo: Bühler Group hot extrusion equipment

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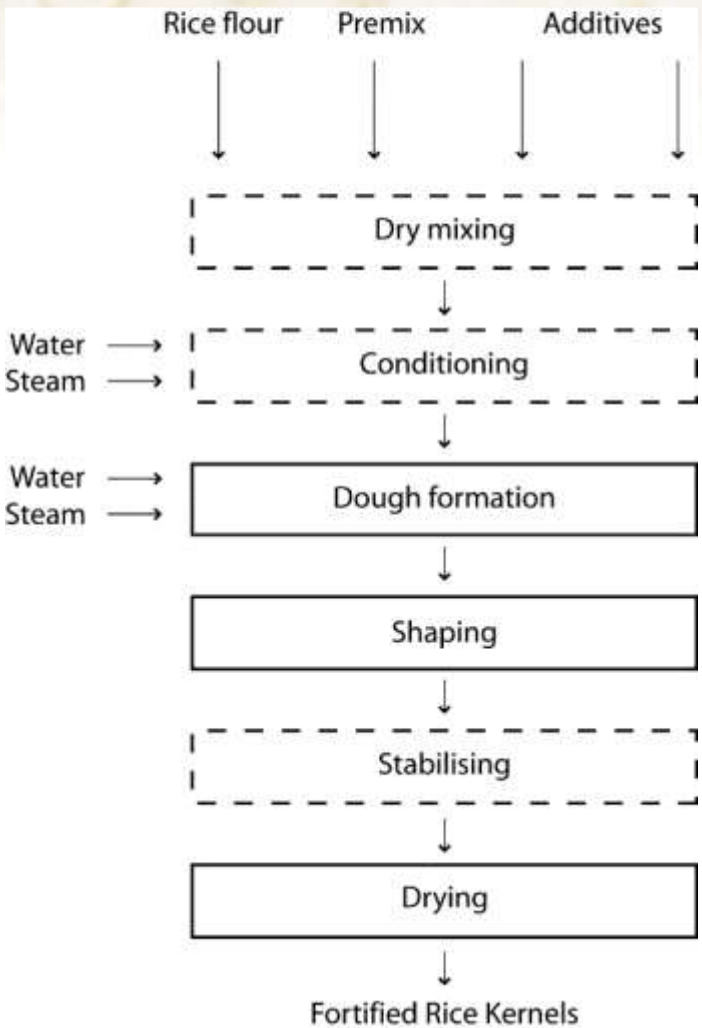
Basic extrusion steps



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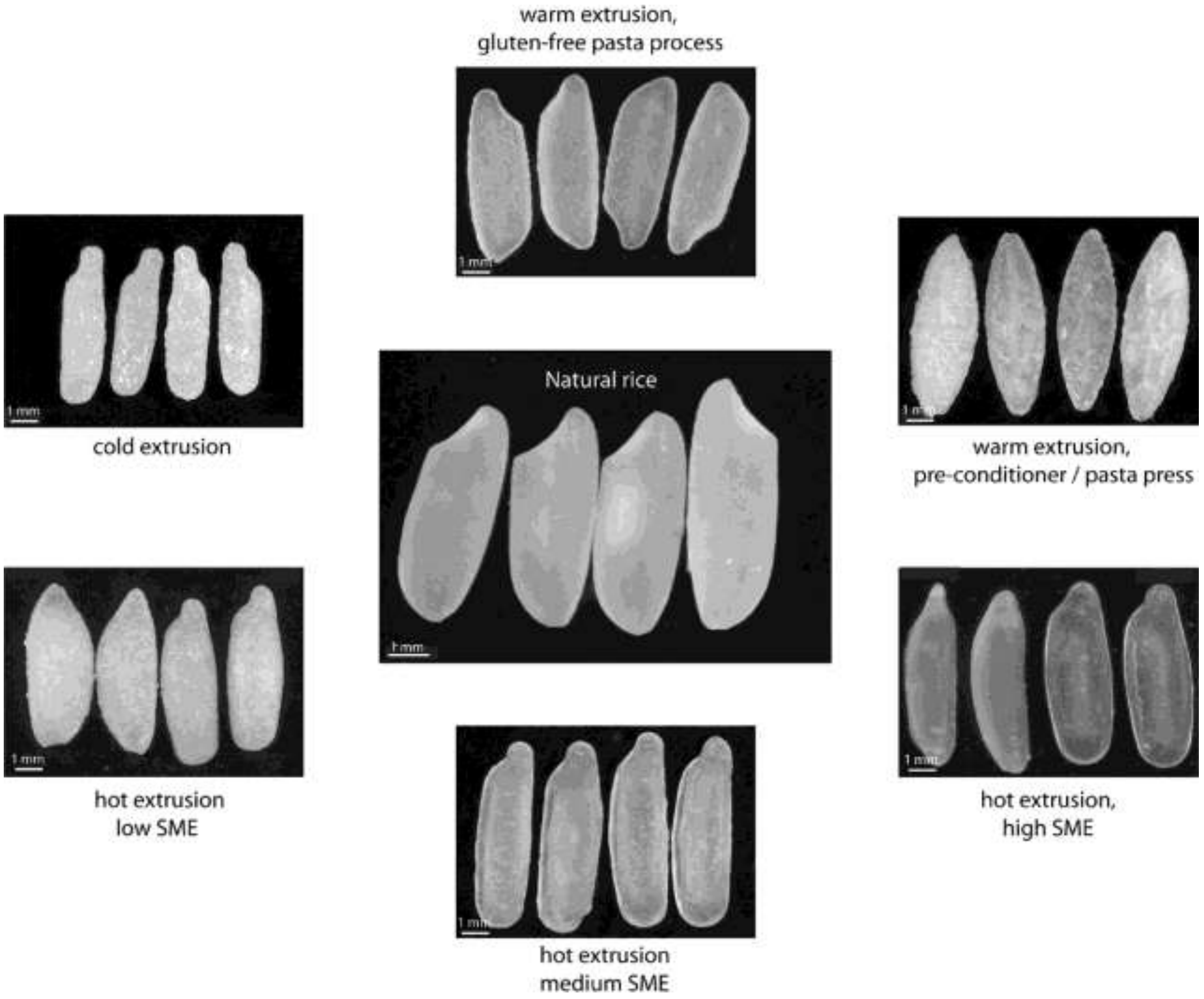
Appearance of fortified kernels



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

For rice, also add MN lost through polishing:

Thiamin

Vitamin B6

Niacin

Commonly added in large scale programs

Many others also possible, such as:

- Vitamin E
- Vitamin D
- Selenium
- Lysine

Possible, but:

- Riboflavin
- Beta-carotene
- Calcium
- Vitamin C
- DHA
- Iodine

De Pee S. Annals NY Acad Sci 2014

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Iron compounds with >80% bioavailability

Iron compound	Relative bioavailability [A]
Ferrous sulfate ($7H_2O$)	100
Ferrous sulfate, dried	100
Ferrous gluconate	89
Ferrous bisglycinate	>100 [B]
Sodium iron EDTA	>100 [B]
Ferrous fumarate	100
Ferrous succinate	92

[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

Iron compound	Relative bioavailability
Ferric orthophosphate	25-32
Ferric pyrophosphate	21-74

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

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Other minerals

	Compounds Used
Zinc	Zinc Oxide (Zinc sulfate)
Selenium	Sodium selenite
Calcium	Calcium carbonate

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Vitamins

Water Soluble	Compound used
Vitamin B1	Thiamine mononitrate
Vitamin B6	Pyridoxine hydrochloride
Vitamin B9	Folic acid
Vitamin B12	B12 1% sd
Vitamin B3 (niacin)	Niacinamide
Vitamin B2	
Fat Soluble	
Vitamin A	A palmitate stabilized with BHT
Vitamin D	Vitamin D stabilized
Vitamin E	Tocopherol acetate
Other	
Beta Carotene	BC 10%WS
Vitamin C	Sodium ascorbate /Ascorbic acid

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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

Wieringa 2014

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.

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