Producing Fortified Rice From Natural Grains via Extrusion

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Need for Fortification

- Rice is a rich source of macro and micronutrients in its un milled form. During rice milling the fat and micronutrient-rich bran layers are removed to produce the commonly consumed starch-rich white rice. White rice is the number one staple food in the rice countries of southeast and northeast Asia, one of the most densely populated regions in the world. Of the world's rice production, 90% is grown and consumed in Asia. On average, 30% of calories come from rice and this can increase to more than 70% in some low-income countries. In most languages of these regions, the words for rice and food are synonymous. It should be noted that rice is also an important staple food in several African, Asian and American countries.

Images of fortified rice

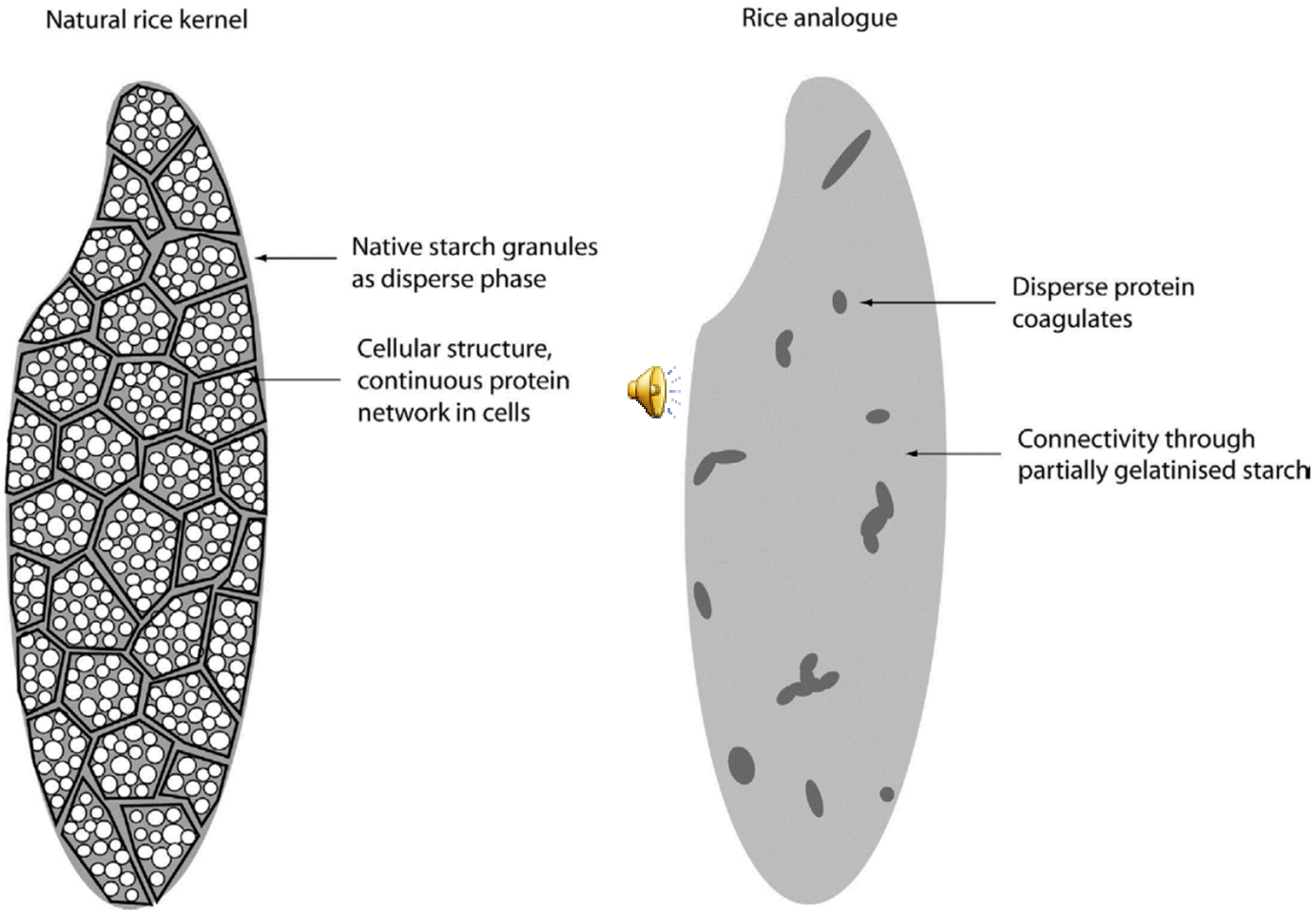
Need for fortification

- Thus, to promote health and well-being of its consumer, it is necessary to modify or "fortify" the natural rice grains, by adding the missing or lost micronutrients like zinc, calcium and certain vitamins so that it solves the problems associated with malnutrition especially in third world countries where Rice is considered a staple diet.

Need for fortification

- The naturally occurring rice modified this way is called as re-constituted or reformed rice and fortification process offers the opportunity not only to compensate for vitamin and mineral losses during the whitening and polishing processes, but to add multiple micronutrients in an adequate complex designed to the local needs of individuals and especially to the exposed groups such as children, pregnant women or geriatric people. The reformed grains are finally added to the natural whole rice grains in a ratio of, for example, 1:100 or 2:100, guaranteeing a controlled intake of the right levels of vitamins and minerals.

The Structure of Native & Reformed Rice Kernel



Rice Fortification Technologies

- 1. Cold Extrusion or “Forming/Shaping”.
- 2. Hot Extrusion or “Cooking”.
- 3. Dusting.
- 4. Coating.

Cold Extrusion in fortification

- This process consists of a Low Shear Pasta type Extruder employed which involves processing the ingredients by running through a Low Shear Screw in a Jacketted Barrel circulated with cool water to prevent excessive temperature rise above 70 Deg. C. In the Cold Extruder, shear is limited and starch is not gelatanized, but the product is formed by extruding through Rice shaped dies and cut into small lengths. This process if also termed as Shape-forming of Rice Analogue. No Steam is used for pre-conditioning the native rice since temperature increase is minimal, the object being just to “form” or shape the products whilst extruding through Rice shaped dies.

Hot Extrusion in fortification

- The hot type or “cooking” process generally uses a medium shear tapered core or multiple flight cooking screw fitted with feeding, conveying, mixing and cooking elements inside a grooved barrel provided with heating/cooling jackets to cook the products homogenously @ max. Temperatures of 110 C. The Hot processes also utilises a pre conditioner mounted atop the Extruder and provided with water and steam injection ports.

Hot Extrusion in fortification

- Freshly extruded & die cut kernels are treated with setting or cross-linking agents to help retain their shape and then they are dried As a last step, kernels are dried. Steam is used in hot extrusion only.
- Hot extrusion results in a high degree of gelatinization (65-85%) depending on specific mechanical energy (SME) input. Single-screw extruders are seldom applied because conveying is inferior. Many modern single screw machines now use grooved or flighted barrels to improve the forward conveying of sticky rice materials.

Hot extrusion in fortification

- Moisture content during extrusion can vary between 12% and 45%.Optimal settings depend on the type of process applied and on raw material characteristics. Moisture contents that are too high leads to excessive stickiness of the dough; values that are too low lead to high mechanical friction exacted during extrusion, which results in an undesirable complete gelatinization of the product. Our own experience has shown that moisture contents between 30% and 40% lead to optimal processing and end-product properties (unpublished observations).

Characteristic of reformed rice

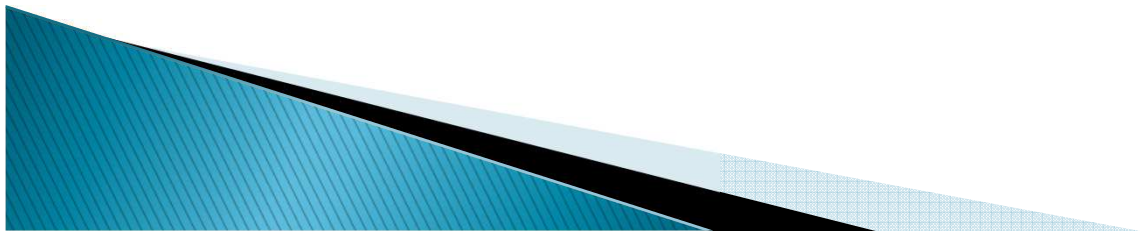
- Reconstituted rice kernels by cold extrusion appear opaque, while warm-extruded kernels produced on an enhanced pasta press appear translucent and more closely resemble natural rice kernels. It has been showed that twin screw-extruded products exhibited superior integrity, flavor, and texture after cooking and less change after overcooking compared with cold-extruded reference products prepared on a conventional pasta press.

Dusting

- 1. Dusting the rice grains with powder form of micronutrients premix.
- 2.Fortificants stick to the grain surface because of strong electrostatic forces.
- 3. This rice should not be cooked with excess amounts of water or rinsed and then drained as fortificants will be lost.
- 4. So this is not practicable in developing economies where rice is rinsed and washed prior to cooking.

Coating

- 1. Liquid (Waxes, gums, fortificants, water)
- 2. Spraying on kernels.
- 3. Rice premix.
- 4. Blending in suitable proportion with native
- rice grains.
- 5. Distinctive colour, smell and taste of reformed rice grain.

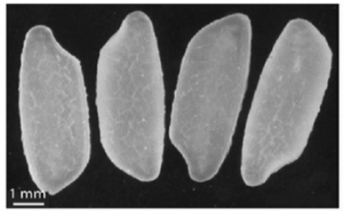


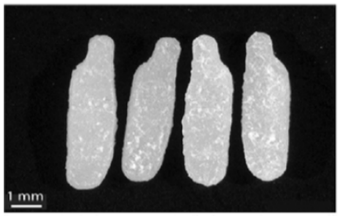
Comparing the technologies

- Of the 4 methods discussed, dusting is least expensive and hot extrusion is most expensive since it involves costly equipment and SME input although it also produces best quality and acceptance by consumer.
- So Hot Extrusion is suggested for producing best quality of fortified rice.
- The Rice-premix developed is blended with natural rice in ratios of 1:50,1:100,1:200 to give fortified rice.

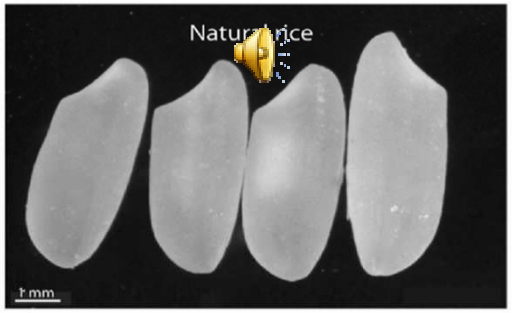
Appearance of Natural and Reformed Extruded Rice

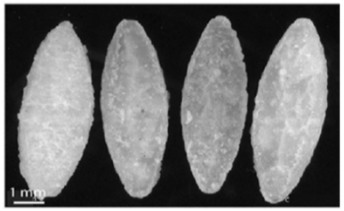
warm extrusion,
gluten-free pasta process



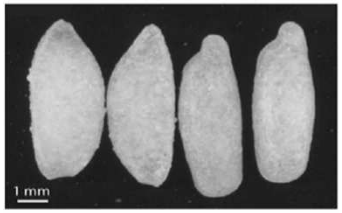


cold extrusion



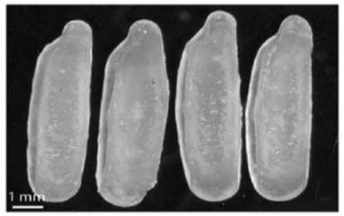


warm extrusion,
pre-conditioner / pasta press



hot extrusion
low SME

hot extrusion,
high SME



hot extrusion
medium SME

Micronutrient for Fortification

Micronutrient	Fortificant form
Iron	FeSO4
Zinc	Zinc Oxide
Folic acid	Folic acid
Vit B12	Cyanocobalamin
Vit A	Vit A palmitate
Thiamin	Thiamin
Niacin	Niacinamide

Hot Extruder & Preconditioner for fortification

5 pass Belt Drier for fortified rice

Cost of Natural & Reformed Rice

- Final costs are dominated by the raw material cost,
- especially of the carrier used, the rice. If the technology
- allows the use of cheap broken rice as starting
- material, it is a cost advantage. This is one of the key
- advantages of extruded fortified kernels. Rice flour
- made from broken rice is the starting material. The
- outcome is kernels similar to intact, non broken rice
- kernels. If the market price difference between broken
- kernels and intact kernels offsets the production
- cost of extruded kernels, then extrusion will be even more
- cheaper than dusting. Coating technologies require
- intact and thus more expensive rice kernels, if the
- coated kernels should have the form of intact rice
- kernels. In some cases broken rice is coated; however,
- broken rice is less appealing.

Cost considerations

- A further cost driver is energy cost. During extrusion,
- irrespective of whether it is cold, warm, or
- hot extrusion, water and/or steam are added, part of
- which has to be removed at the end of the process.
- The drying step is far more costly than the preconditioning step (in warm and hot extrusion) and the extrusion process itself. Drying is usually done either by using a fluid bed or pasta dryers and is energy intensive. Thus, the additional costs of fortification for rice millers might vary substantially in the range of 3-6% of bulk rice costs.

Conclusion

- Rice fortification can make significant contribution towards fulfilling micronutrient deficiencies.
- Fortified rice looks very similar and smells/tastes similar to non fortified rice.
- Hot extrusion is suggested for rice fortification
- As rice fortification is scaled up, it will reduce costs by achieving economies of scale.
- Fortified rice has good sales appeal to consumer.

Thank you!

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