Introduction to Rice Fortification

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Key Messages

- Where rice is a staple food, and micronutrient deficiencies are widespread, making rice more nutritious by fortifying it with essential vitamins and minerals can make a significant contribution to addressing micronutrient deficiencies and improving public health.
- Decades of experience have proven that large-scale food fortification is a sustainable, safe and effective intervention with significant public health impact.
- Rice fortification, like all other food fortification, should be one intervention within a broad multisectoral strategy to improve micronutrient health.
- Current technology can produce fortified rice that is safe, and that looks, tastes and can be prepared the same as non-fortified rice. Consumption of fortified rice increases micronutrient intake without requiring consumers to change their buying, preparation or cooking practices.
- Large-scale rice fortification is most successful when driven by a multisectoral coalition, which includes national government, the private sector, and civil society organizations.
- Rice fortification has the greatest potential for public health impact when it is mandated and well regulated. When this is not feasible, the fortification of rice distributed through social safety nets is an effective alternative to reach populations who can most benefit.
- The cost of rice fortification is determined by context-specific variables. Thus, it is not possible to calculate a universal cost figure. However, based on experience in 15 countries, four of which are in Asia, the retail price for fortified rice may rise by from 1% to 10%. As rice fortification is scaled up, it will achieve economies of scale, which will reduce costs.

Introduction

Micronutrient deficiencies affect more than two billion people worldwide and are especially prevalent in developing countries. Also referred to as Hidden Hunger, micronutrient deficiencies impair physical growth and cognitive development and have long-term effects on health, learning ability, and productivity. Consequently, micronutrient deficiencies increase morbidity and mortality across the lifespan and have a negative impact on social and economic development.[1]

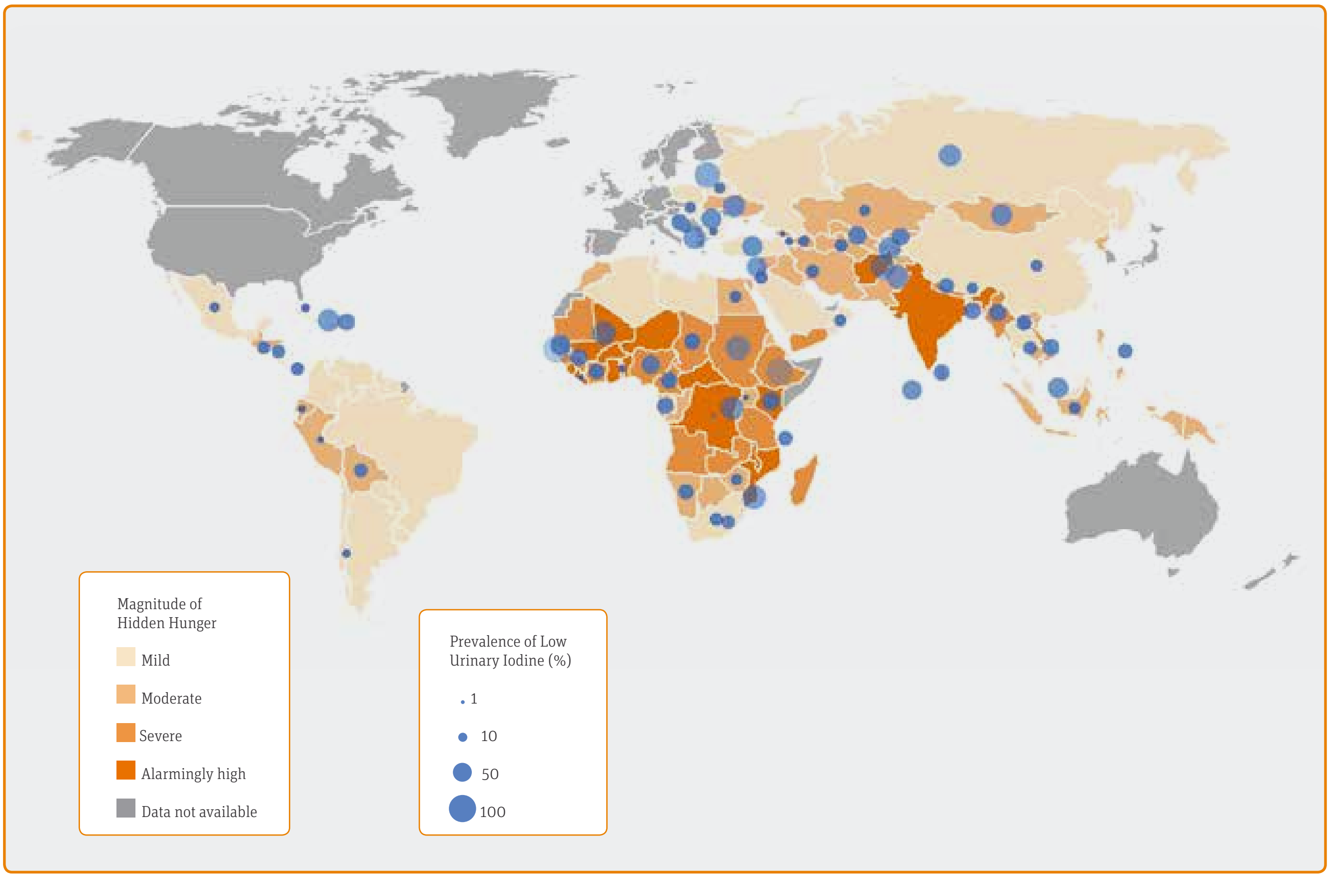
Rice is a staple food for more than three billion people across the globe. In some countries, including Bangladesh, Cambodia and Myanmar, rice contributes as much as 70% of daily energy intake. This presents a nutritional problem: milled rice is a good source of energy, but a poor source of micronutrients.[2] Therefore, where rice is a staple food, making it more nutritious through fortification with essential vitamins and minerals is a proven and cost-effective intervention to increase micronutrient intake among the general population.[3]

> "Rice is a staple food for more than three billion people across the globe"

The Lancet 2008[4] and 2013[5] Maternal and Child Nutrition Series, the Copenhagen Consensus[6] and Scaling Up Nutrition (SUN) Movement all recognize and endorse staple food fortification as a sustainable, cost-effective intervention with a proven impact on public health and economic development. Reducing micronutrient deficiencies and undernutrition has the potential to reduce by more than half the global burden of disability for children under age five, to prevent more than one third of global child deaths per year, and, in Asia and Africa, to boost GDP by up to 11%.[7]

This article provides an overview of large-scale rice fortification, and highlights important considerations for its introduction, implementation and scale-up. For definitions of the terminology presented in this article, please refer to the glossary (p.223).

FIGURE 1: Hidden Hunger Map[11]



Importance of addressing micronutrient deficiencies

Micronutrient deficiencies occur when a diverse and nutrient-rich diet (i.e., one that includes animal-source foods such as meat, eggs, fish, dairy, as well as legumes, cereals, fruits and vegetables) is neither consistently available nor consumed in sufficient quantities. In addition, gut inflammation and illnesses (such as diarrhea, malaria, helminthiasis [worms], TB, and HIV/AIDS) affect a person's ability to absorb micronutrients and can lead to deficiencies. In low- and middle-income countries (LICs and MICs) multiple micronutrient deficiencies tend to coexist, as they share common causes.[5]

Although more prevalent in LICs and MICs, micronutrient deficiencies also represent a public health problem in industrialized nations and in populations suffering from overweight and obesity. The increased consumption of highly processed, energy-dense but micronutrient-poor foods in industrialized countries, and in countries in social and economic transition, is likely to adversely affect their populations' micronutrient intake and status.[1]

Deficiencies in iron, zinc and vitamin A are the most common types of micronutrient deficiencies, and are among the top ten causes of death through disease in developing countries. In addition, deficiencies in B vitamins, iodine, calcium and vitamin D are also highly prevalent.[1] **Figure 1** demonstrates the global landscape of micronutrient deficiencies, also called Hidden Hunger.

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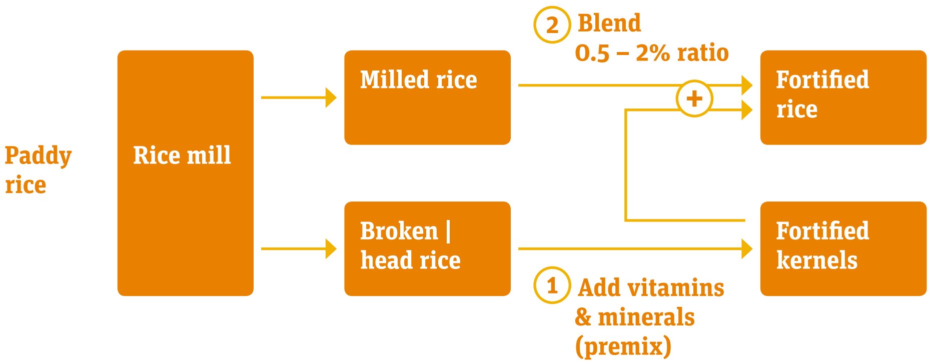
Rice fortification: Cost-effective intervention to improve micronutrient health

While milled rice is a good source of energy, it is a poor source of micronutrients. Therefore, in countries with widespread micronutrient deficiencies and large per capita rice consumption, making rice more nutritious through fortification can effectively increase micronutrient intake.[3] Decades of experience and evidence have proved that large-scale staple food and condiment fortification is a safe and cost-effective intervention to increase vitamin and mineral intake among the general population.

FIGURE 2: Two-step rice fortification manufacturing process



Rice fortification builds upon the global success and long-established evidence base for safe and effective flour and salt fortification programs. Wheat and maize flour have been successfully fortified with iron, folic acid and other micronutrients for more than 60 years. Salt's nearly century-old history of iodine fortification has resulted in a dramatic reduction in global iodine deficiency.

From a regulatory, public health and nutrition point of view, rice fortification is very similar to maize and wheat flour fortification. However, from an implementation and technical perspective, fortifying rice differs significantly from fortifying flour.

Rice fortification, like other food fortification, should be one component of a larger integrated and multisectoral strategy to improve micronutrient health that aims to improve dietary diversity and infant and young child feeding practices. This is because the consumption of fortified foods on their own will fall short of fulfilling micronutrient gaps for groups with relatively high micronutrient needs. For example, target populations such as young children and pregnant or lactating women will require additional micronutrient supplementation to meet their requirements. In addition, improved sanitation, good hygiene practices, and accessible and high-quality preventive and curative health services are essential to sustain a population's good micronutrient health.

In the 1940s, the Philippines began fortifying rice with thiamin, niacin and iron. This resulted in the successful elimination of beriberi, a severe public health problem caused by thiamin deficiency. In 1952, the Philippines pioneered the first mandatory rice fortification legislation requiring all rice millers and wholesalers enrich the rice they milled or traded.[8]

Since these early efforts, the past decade has seen a significant evolution of cost-effective rice fortification technologies that are unlocking opportunities to significantly contribute to the reduction of micronutrient deficiencies. Affordable technology is available to produce fortified rice that looks, smells and tastes the same as non-fortified rice, with its nutrients retained after preparation and cooking. Thus, micronutrient intake can be increased without requiring consumers to change their rice buying, preparation, or cooking practices.

> "The past decade has seen a significant evolution of cost-effective rice fortification technologies"

Rice fortification technology and production

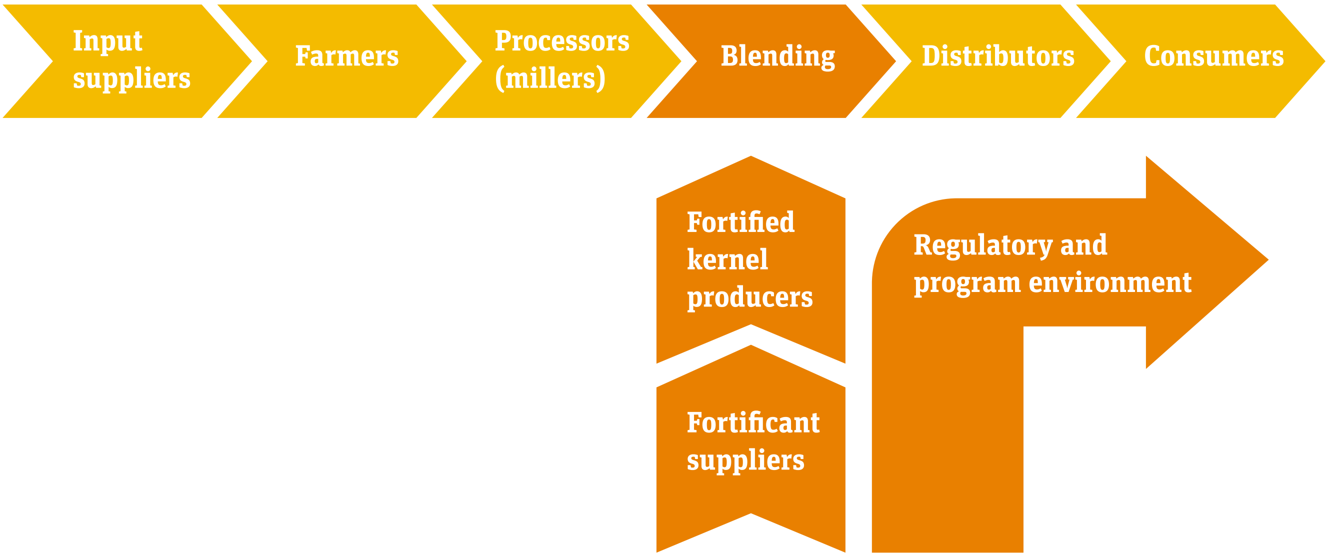
As illustrated in **Figure 2**, rice fortification that retains micronutrients after preparation and cooking includes a two-step process involving the formation of fortified kernels containing appropriate vitamins and minerals, and blending of the fortified kernels with milled rice to create fortified rice.

Extrusion and rinse-resistant coating technologies produce fortified rice that is effective and acceptable to consumers (color, taste and texture). The type of fortificants chosen and the technology used ensure that fortificants remain stable and bioavailable under different conditions of storage, transportation, preparation, and cooking. For additional information on fortification technologies, please refer to the contribution by Montgomery et al (p. 159).

As shown in **Figure 3**, when rice fortification is introduced, the rice supply chain is adapted to incorporate fortified kernel production and blending. This also requires the integration of additional quality assurance, quality control and regulatory monitoring.

Conducting a rice landscape analysis (pp. 199–209) is strongly recommended to determine how to integrate fortified kernel production and blending into the rice supply chain, and to assess the potential health impact. The integration of the

FIGURE 3: Rice fortification supply chain



additional fortification steps has to take into account the following aspects: the structure and capacity of the rice industry; the complexity of the existing rice supply chain; the existing distribution channels; consumer consumption and purchasing preferences; and the policy and regulatory environment. Results of the rice landscape analysis also provide valuable information for strategic decisions regarding the delivery options for fortified rice, which stakeholders to engage, and how to adapt the regulatory and policy environment.

Recommended micronutrients for inclusion in fortified rice

From a public health and nutrition point of view, the research and recommendations related to wheat flour fortification can also be applied to rice fortification. However, it is important to consider the differences between rice and flour in terms of nutrient content and any technological aspects that warrant changes of the recommendations when fortifying rice instead of flour. Based on the evidence available, it is recommended to consider fortification with the following micronutrients: iron, vitamin A, vitamin B9 (folic acid), vitamin B6 (pyridoxine), vitamin B12 (cobalamine), vitamin B1 (thiamin), vitamin B3 (niacin) and zinc.[9] However, the determination of which micronutrients should be included and at what level depends on the target population's micronutrient intake, the prevalence of micronutrient deficiencies, and access to, and consumption of, other fortified foods. Each country introducing rice fortification will need to develop fortification standards, taking into account its local micronutrient situation and existing micronutrient interventions. For additional information on the evidence for recommended micronutrients and standards, please refer to the contributions de Pee et al (Trials, p. 143 and Standards, p. 165).

"From a public health and nutrition point of view, the research and recommendations related to wheat flour fortification can also be applied to rice fortification"

Target populations for rice fortification

The potential for individuals to benefit from rice fortification varies across the course of a lifetime, and depends on micronutrient requirements, dietary intake, the amount of rice consumed, and the potential of fortified rice to fill micronutrient gaps. For example, women of reproductive age (19–45 years old) have moderate to high micronutrient requirements and consume a significant amount of rice. Therefore, they are likely to consume a sufficient quantity of fortified rice to meet their micronutrient needs. However, pregnant women have increased micronutrient needs. Although the fortified rice they consume will help meet these needs, it is unlikely to fully meet them. Therefore, other interventions such as iron/folate or multiple micronutrient supplementation will still be required. Young children aged 6 to 23 months, likewise, have relatively high micronutrient needs, yet consume only small quantities of rice. Therefore, fortified rice will not be sufficient to fill their micronutrient gap. For

Extruded fortified rice

additional information on specific micronutrient needs across the lifecycle, please refer to **Figure 4** in the contribution by Rudert et al (p. 193).

Potential delivery options for fortified rice

To achieve public health impact, it must be feasible and sustainable to fortify a significant portion of the rice consumed, especially for the target populations that can most benefit from its consumption. Mandatory fortification, in which legislation and regulations require the fortification of all rice to a specific standard, has the greatest potential for public health impact. When fortification is well regulated and enforced, the entire population will consume fortified rice without having to change purchasing or consumption practices. Costa Rica has successfully implemented mandatory rice fortification since 2001. For additional information on Costa Rica's successful experience, please refer to the contribution by Tacsan et al (p. 212).

Mandatory fortification may not always be feasible, due to the structure of the rice industry, the complexities of the rice supply chain, lack of political will, and other contextual factors. Therefore, the fortification of rice distributed through social safety net programs provides an alternative delivery option to reach groups who can most benefit from the consumption of fortified rice. This entails fortifying rice distributed for free, or at a subsidized cost, through school feeding programs, emergency distributions, or other programs that support lower socioeconomic groups.

Voluntary fortification is a market-driven approach in which fortified rice is marketed as a "value-added" product to consumers. This delivery option has limited potential to achieve a significant public health impact, as it relies on consumer awareness, demand generation and the willingness and ability to pay slightly more for the fortified rice. For additional information on delivery options for fortified rice, please refer to the contribution by Codling et al (p. 170).

"The cost of rice fortification is determined by a multitude of context-specific variables, and thus it is not possible to calculate a universal cost figure"

Cost of rice fortification

The cost of rice fortification is determined by a multitude of context-specific variables, and thus it is not possible to calculate a universal cost figure. The cost of fortified rice will depend upon the structure and capacity of the rice industry, the complexity of the rice supply chain, the policy and regulatory environment, and the scale of the relevant program. However, based on the experience thus far in 15 countries, four of which are in Asia, the retail price increase for fortified rice ranges from an additional 1% to 10%. As rice fortification expands, production and distribution achieve economies of scale and costs are reduced.[10]

During the introductory phase of rice fortification costs will be incurred for mobilizing stakeholder support, conducting a rice landscape analysis, developing a business case, carrying out trials for logistical feasibility and consumer acceptability, policy development, and general project management. The rice landscape analysis will inform strategic decisions regarding the source and production of fortified kernels, blending locations, delivery options, and the scale of operations. During the implementation phase, capital investments will be needed and recurring costs will be incurred for the production and distribution or sale of fortified rice. Recurring costs include fortified kernel production, transportation, blending, quality assurance and quality control, as well as continuing policy development and general project management. In the scale-up phase, fortified rice production and distribution expand. This expansion should result in greater efficiency of the supply chain, and economies of scale.

Conclusion

The number of countries introducing rice fortification is growing, with Asian and Latin American countries spearheading the effort. Fortifying rice, a staple food for more than three billion people globally, has the potential to improve population health, increase productivity, and promote economic development. Rice fortification has benefitted from the experience of wheat and maize flour fortification. Considerations for rice fortification programs include appropriate decisions on the fortificant premix, fortification technology, the supply chain, delivery options, and the regulatory and monitoring environment. The evolution of cost-effective technologies, combined with data on effective nutrient fortification levels, makes rice fortification safe, feasible, effective, and sustainable. Costs are context-specific and, as programs expand, economies of scale will be achieved and costs will decline. Strong advocacy is needed to further drive the public-private partnerships and the government mandates that help ensure long-term success.

The potential impact of improving micronutrient health in Asia, Latin America and beyond is vast. The time is right – there is great momentum to move forward with rice fortification from a growing number of governments, private sector leaders, and key global health organizations. Asia and Latin America can seize the momentum and lead the way in building effective and sustainable rice fortification programs.

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