



Scaling up Rice Fortification in Asia



**World Food
Programme**

Table of Contents

Introduction | **04**

An Important Milestone for Rice Fortification | **07**

Scaling Up Rice Fortification in Asia
Workshop Bangkok 2014 | **08**

Introduction to Rice Fortification | **12**

Highlights from Technical Consultation Meeting | **18**

Overview of Evidence and Recommendations
for Effective Large-Scale Rice Fortification | **20**

Addressing Myths and Misconceptions about
Rice Fortification | **26**

Linking Rice Fortification Opportunities with
Nutrition Objectives | **31**

Identifying Appropriate Delivery Options for Fortified Rice | **37**

Landscape Analysis for Rice Fortification | **43**

Infographic: Fortified Rice Supply Chain | **50**

Standards and Specifications for Fortified Rice | **52**

Technology for Rice Fortification | **57**

Costs and Financing for Rice Fortification | **63**

Lessons Learned from Flour and Salt Fortification | **68**

Rice Fortification in Costa Rica: Case study | **73**

Case Study: Bangladesh | **79**

Bangkok Rice Fortification Workshop: Delegations | **84**

Glossary | **88**

Imprint | **91**

Introduction

Now is the right time to scale up rice fortification

Rice fortification is the enrichment of rice with essential vitamins and minerals post-harvesting to increase its nutritional value. With more than three billion people relying on rice as a staple food, rice fortification offers a unique opportunity to substantially improve nutrition and, as such, the health and economic status of a large number of people in many countries at a very low cost.

Hidden hunger

Globally, more than two billion people are affected by micronutrient deficiencies, also known as hidden hunger. Micronutrient deficiencies, defined as the lack of one or more of the essential vitamins and minerals required for healthy growth, development, and functioning, affect all ages and socioeconomic groups. The consequences of hidden hunger, however, are particularly damaging for women of reproductive age and their children. Its short- and long-term consequences impact household and national level socioeconomic development, and include maternal and child mortality, increased illness, mental retardation, and poor cognitive and physical development. All of these negatively impact a country's GDP. As affirmed by the 2008 and 2013 Lancet Series on Maternal and Child Nutrition, the 2012 Copenhagen Consensus and the global Scaling Up Nutrition (SUN) Movement, multi-micronutrient fortification is among the most cost-effective strategies to reduce undernutrition.

Rice fortification in context

From a regulatory and public health point of view, rice fortification is similar to the fortification of wheat and maize flour and salt – all of which have been proven effective at a large scale and are recommended by the World Health Organization (WHO). The programmatic experience and evidence base established through national-scale fortification of wheat and maize flour and salt can be used to inform the introduction and expansion of rice fortification. In addition, WHO is developing global recommendations on rice fortification, based on a review of efficacy, effectiveness, and programmatic experience to date.

Today, affordable technology exists to produce fortified rice kernels that look and taste the same as non-fortified rice. Due to advances in coating and extrusion technologies, the micronutrients are retained effectively through a multitude of preparation and cooking methods including extensive washing, and long

cooking times. The latest technology offers the benefits of rice fortification without requiring consumers to change any of their buying, cooking, or eating habits.

Improving micronutrient intake

This publication provides a comprehensive overview of how fortifying rice with multiple essential vitamins and minerals can be an effective and sustainable strategy to improve micronutrient intake, and thus contribute significantly to improved health and economic status. This special supplement is based on the presentations given during the September 2014 Scaling Up Rice Fortification workshop held in Bangkok, Thailand, co-organized by the Food Fortification Initiative (FFI) in Asia, the Global Alliance for Improved Nutrition (GAIN), the Micronutrient Initiative (MI), PATH, the United Nations Children's Fund (UNICEF), and the United Nations World Food Programme (WFP).

The series of articles explains the principles of rice fortification, provides an overview of the evidence, and elucidates some of the misconceptions associated with rice fortification. The various contributions compile the latest evidence, information, and programmatic experience on rice fortification. Rice fortification programming components are presented, including the linkage between fortification and achieving nutrition objectives, and how to conduct a landscape analysis to inform strategic decision-making when developing a rice fortification program. Articles contained here also explore important considerations for identification of the most appropriate delivery channels and technologies for fortified rice. The significance of developing standards and the factors which influence the cost of rice fortification are also explained. The supplement concludes with lessons learned from flour and salt, and rice fortification programs in Bangladesh and Costa Rica.

Now is the right time to scale up rice fortification. Affordable technology is available; the evidence base is sufficient to start, and expanding; and an increasing number of countries are interested and are already gaining experience in rice fortification.

We wish you success in your rice fortification efforts.

Guest Editors:

Karen Codling, Cecilia Fabrizio, Katrien Ghoois, Jennifer Rosenzweig, Judith Smit and Rizwan Yusufali



Extruded fortified rice in a bowl



Schoolchildren queuing up for a fortified rice mid-day meal in a government school in Gajapati, Odisha, India

An Important Milestone for Rice Fortification

Momentum and commitment to introduce and scale up rice fortification as an effective strategy to address micronutrient deficiencies is growing within government institutions, the rice industry, the private sector, aid agencies, research institutes, and donors. With this, government and non-government stakeholders are increasingly seeking up-to-date technical information and programmatic experience to inform their decision-making on rice fortification.

In response, towards the end of 2013 representatives from the Asia regional offices of the Food Fortification Initiative (FFI), the Global Alliance for Improved Nutrition (GAIN), the Micronutrient Initiative (MI), PATH, the United Nations Children's Fund (UNICEF) and the United Nations World Food Programme (WFP) formed a committee to organize the first regional rice fortification workshop: "Scaling Up Rice Fortification in Asia." There was consensus within the committee that this was the opportune time to bring together the key stakeholders and experts to share the latest technical information and policy developments, discuss the evidence base, exchange programmatic experiences and lessons learned, and discuss the next steps to advance rice fortification in Asia.

"There was consensus within the committee that this was the opportune time to bring together the key stakeholders and experts"

The members of the organizing committee came together to collaboratively develop a participatory workshop in which different elements of a sustainable and well-designed rice fortification strategy could be discussed and best practices shared. This created the opportunity for informative presentations by experts, as well as information-sharing among participants.

This special *Sight and Life* supplement contains articles based on the workshop proceedings and aims to provide an overview of the relevant information needed to introduce and scale up rice fortification as a strategy to reduce micronutrient deficiencies.

Each of the organizing agencies remains committed to providing continuous technical support in Asia and beyond to facilitate implementation of rice fortification at scale.

Most importantly, the organizing committee again shares its appreciation for the key contributions of the nine country delegations and the rice fortification experts. This is what made the workshop a success and an important milestone for rice fortification.

The Organizing Committee

A special thank-you goes to the members of the organizing committee: Arvind Betigeri (PATH), Karen Codling (Food Fortification Initiative), Melanie Galvin (Micronutrient Initiative), Katrien Ghooos (World Food Programme), Jennifer Rosenzweig (World Food Programme), Christiane Rudert (UNICEF), Judith Smit (World Food Programme), Anuj Srivastava (Micronutrient Initiative) and Rizwan Yusufali (GAIN).



Scaling Up Rice Fortification in Asia

Workshop Bangkok 2014

The Scaling Up Rice Fortification in Asia workshop, held in Bangkok, Thailand, (September 2014), brought together 200 stakeholders including government decision-makers and technical staff, and national, regional and global technical experts from a range of institutions and agencies including the United Nations (UN), non-governmental organizations (NGOs), academia, the private sector, and donors. Country delegations attended from Bangladesh, Cambodia, Indonesia, India, Lao PDR, Myanmar, Nepal, Philippines, and Sri Lanka. The workshop was the result of a collaborative effort by the Food Fortification Initiative (FFI), the Global Alliance for Improved Nutrition (GAIN), the Micronutrient Initiative (MI), PATH, the United Nations Children's Fund (UNICEF), and the UN World Food Programme (WFP).

The objectives of the scaling up rice fortification workshop were to:

- share current global and regional evidence and operational experience;
- facilitate exchanges between countries at differing implementation stages of rice fortification; and
- create a network for continued learning and knowledge exchange in support of national efforts to scale up rice fortification.

The workshop combined plenary presentations with facilitated exchanges, interactive country delegation work groups, and a market place of 20 exhibitors. Participants learned about the global evidence for rice fortification, and the technical aspects of policy and production, which were further illustrated with case studies. Throughout the workshop, technical presentations were interspersed with opportunities for country delegation teams to discuss the applicability and feasibility of rice fortification. The country teams concluded their discussions with specific action points to move rice fortification forward in the next 18 months.

Most of the presentations given during the four day workshop were collaboratively drafted, reviewed and presented on behalf of the organizing committee. In addition, the Ministry

of Health of Costa Rica and the Philippine Country Delegation presented their specific experiences. The World Health Organization also presented on guideline development.

Highlights of the workshop

The articles contained in this supplement are based on the technical presentations given during the September 2014 Scaling Up Rice Fortification in Asia workshop.

“Rice is an ideal fortification vehicle and fills a gap in the current fortification landscape”

The opening presentation *“Introduction to Rice Fortification”* emphasized that staple food fortification, including rice fortification, is a cost-effective strategy to address micronutrient deficiencies, when part of an integrated program to improve micronutrient health. With over three billion people relying on rice as a staple food, most of whom reside in Asia, rice is an ideal fortification vehicle and fills a gap in the current fortification landscape.

The presentation *“Overview of Trials and Evidence”* summarized the global evidence for the benefits of fortifying rice to increase micronutrient intake, provided the rice is correctly fortified and is consumed in adequate quantities by the populations in need.

The presentation *“Myths and Misconceptions”* confirmed that rice fortification is safe for all population groups. Fortified milled rice will increase nutrient intake and will provide more nutrients than either biofortified or brown rice. However, rice fortification cannot eliminate all micronutrient deficiencies and, therefore, should be part of a more comprehensive strategy to address micronutrient deficiencies.

The presentation *“Standards for Rice Fortification”* emphasized that government standards ensure the safety, acceptability, and nutrient content of fortified rice for the benefit of both consumers and manufacturers. Recommended micronutrient

standards for fortified rice are based on recommendations for wheat and maize flour fortification.

As explained in the presentations *“Delivery Options and Current Status of Rice Fortification”* and *“Linking Rice Fortification with Nutrition Objectives”*, determining the best delivery option for fortified rice is country-specific. It depends upon the rice supply chain (including availability of fortified kernels), the intended public health impact for specific target groups, the availability and effectiveness of social safety systems, and the policy and legislative framework. Mandatory fortification is considered to have the greatest potential for public health impact, as it can reach a large proportion of the population. When this is not feasible, fortification of rice distributed through social safety nets is a good alternative to reach groups at high risk of micronutrient deficiencies.

“Determining the best delivery option for fortified rice is country-specific”

The presentation *“Lessons Learned from Flour and Salt Fortification”* shared key success factors with application to rice fortification. Both flour and salt have achieved remarkable public health success globally. Industry consolidation is key to effective monitoring and program sustainability. National partnerships and long-term industry and government commitment underpin successful programs. Mandatory legislation yields the best results, but needs to be accompanied by adequate regulatory, coverage and impact monitoring. While advantageous to raise public awareness of the benefits of rice fortification, in the context of mandatory fortification it is not necessary to create consumer demand, as all the rice sold is expected to be fortified.

The *“Technology for Rice Fortification”* presentation detailed several methods of fortification. Extrusion and rinse-resistant coating are the best technologies currently available to produce fortified kernels that are stable during different conditions of storage, preparation and cooking, and that meet the sensory requirements of consumers.

The costs of introducing and scaling up rice fortification are context-specific. As explained in the *“Cost and Financing”* presentation, costs must be analyzed across the country-specific rice supply chain. Cost factors should include: different types of initial investment costs, recurrent costs such as the production of fortified kernels, transport of kernels to blending sites, blending of kernels with non-fortified rice, sales and distribution, regulatory, coverage and impact monitoring. The variability of these costs by context and scale of the program make it

difficult to estimate a standard cost for fortified rice. However, experience in different countries has been that the estimated retail cost will increase from one to ten percent depending on context and scale.

Country delegation working groups

Throughout the workshop, country delegates analyzed their specific situations, and identified opportunities for the expansion and scale-up of rice fortification. In the first working group session, country delegates considered *the rice supply chain*, including where rice is grown, where and how it is milled, and how it is distributed. This analysis was then used in the second working group session to identify *the most appropriate delivery options* for reaching the target groups who could most benefit from fortified rice. In this exercise, several delegations recognized that with a fragmented rice market, distribution of fortified rice through social safety net programs offers a good alternative to mandatory fortification.

In the third working group session, delegates discussed *requirements to operationalize* selected delivery options across the fortified rice supply chain. In the final working group, *teams identified potential actions to be taken over the next 18 months* to move rice fortification forward in their country. Actions varied by country, and included: setting fortification standards, organizing national stakeholder meetings and study tours, conducting a detailed rice landscape analysis, setting up local fortified kernel production, making a business plan, and conducting field research, micronutrient surveys and learning visits.

Country experiences

Luis Tacsan, from the Ministry of Health Costa Rica, shared lessons learned from the scale-up of rice fortification. Costa Rica’s experiences demonstrated that an integrated program to address micronutrient health that is inclusive of mandatory food fortification can create a significant public health impact. Costa Rica has legislated mandatory fortification for many widely consumed commodities, such as wheat and maize flour, milk, salt, and sugar. Legislation for mandatory salt fortification was passed as early as 1970, and for mandatory rice fortification in 2001. Studies have shown significant reductions in the population’s micronutrient deficiencies, which can be attributed to the comprehensive mandatory fortification efforts. For rice, fortification levels were based on the in-country micronutrient needs and were balanced with the fortification levels for other commodities. Universal rice fortification coverage has been achieved through a visible political commitment and a strong public-private partnership. Importantly, Costa Rica has reliable regulatory and enforcement systems in place.

The Philippines passed mandatory legislation in 2001 and has done significant planning, yet less than one percent of rice

is currently fortified. Initially the government put in place a work plan that projected implementation in phases, with the largest mills fortifying first. Despite significant efforts on the part of the National Food Authority, the private sector has not chosen to engage in large-scale rice fortification. Issues include a fragmented milling industry landscape and the low capacity of the thousands of small millers to fortify. There are also additional problems of technology constraints, complexity of the supply chain for fortified kernels, and geographic logistical challenges. As a result, the government has not actively tried to enforce universal rice fortification.

Market place

Over 20 exhibitors representing the public and private sector participated in the market place to share information on projects, blending and fortification experiences, and examples of quality control toolkits. Samples of fortified kernels produced using coating and extrusion technology were also on display. Exhibitors also offered opportunities to taste different types of fortified rice, to demonstrate that the rice looks, smells, and tastes very similar to non-fortified rice.

“Fortified rice looks, smells, and tastes very similar to non-fortified rice”

Donor perspectives

During a panel discussion, donors, including the Asian Development Bank, the European Union, the World Bank, the Australian Department of Foreign Affairs and Trade, the government of the Netherlands, and the United States Department of Agriculture (USDA), shared their regional and global nutrition-related strategies. Rice fortification is seen as a new area of interest and, as an intervention to improve both public health and economic indicators, it fits well within their nutrition objectives. USDA and the Netherlands currently support large-scale rice fortification programs and research, and the USDA representative predicted significant increases in fortified rice as part of US food aid.

Primary conclusions and lessons learned

There is a high level of interest in large-scale rice fortification in Asia, from governments, the private sector, technical partners and donors. Countries can build on the lessons learned from experiences with wheat flour and salt fortification. These commodities are similar to rice from a regulatory, public health and nutrition point of view; however, they have different implementation and technical issues. Although the evidence from large-scale effectiveness programs is not complete, there is now suf-

ficient evidence to move ahead with scaling up fortified rice as part of an integrated program to improve micronutrient health.

Successful rice fortification is country- and context-specific, and requires careful planning and analysis, multisectoral partnerships, and engagement of the private and public sectors. Therefore, a rice landscape analysis to assess the rice supply chain, market attractiveness, and ease of implementation is necessary to inform strategic decision-making regarding the introduction, implementation, and scale-up of rice fortification as explained in the presentation on landscape analysis.

There are challenges to large-scale implementation. The scattered and decentralized milling landscape complicates large-scale production of high-quality fortified rice. However, many countries are working towards consolidation of the rice value chain to address this issue. In addition, advocacy and information-sharing are essential to drive the political will to develop and scale up a rice fortification program.

“Advocacy and information-sharing are essential to drive the political will to develop and scale up a rice fortification program”

Mandatory fortification has the greatest potential to achieve public health impact; however, due to the fragmented structure of the rice industry, it may not be feasible in all countries. Large-scale social safety nets offer an alternative to reach the most vulnerable populations with fortified rice.

The strategic timing of this workshop was not a coincidence. The organizing members aimed to further build on the existing momentum, interest, and available evidence and experience. The workshop created a platform for the technical experts, government technical decision-makers, the private sector and donors to discuss the evidence and share their experiences. Country delegation working groups were able to begin working through the steps towards development of a rice fortification program. It is the organizers' intent that this special *Sight and Life* supplement will formalize the learning from the workshop and that the spirit of collaboration and support in the workshop will carry on to successful implementation of rice fortification programs throughout Asia and, hopefully, beyond!

“Precious things are not pearls
and jade but the five grains,
of which rice is the finest”

Chinese Proverb



Paddy rice harvest in Nepal

Introduction to Rice Fortification

Peiman Milani

PATH

Cecilia Fabrizio, Jennifer Rosenzweig

World Food Programme Regional Bureau for Asia

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 multi-sectoral 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 multi-sectoral 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

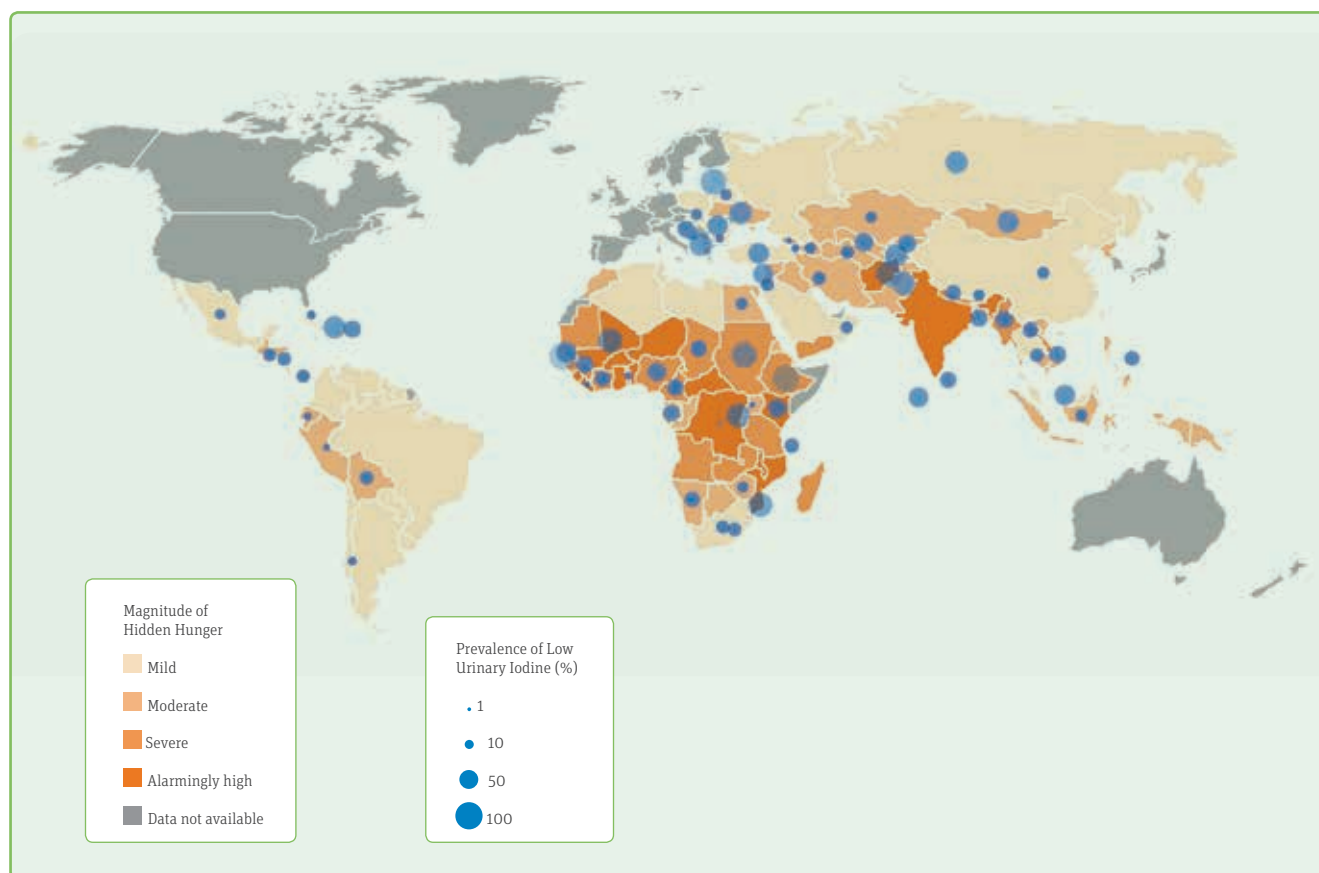
Micronutrient deficiencies affect more than two billion people worldwide and are especially prevalent in developing countries. Also referred to as hidden hunger, micronutrient deficiencies impair physical growth and cognitive development and have long-term effects on health, learning ability, and productivity. 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 2008⁴ and 2013⁵ Maternal and Child Nutrition Series, the Copenhagen Consensus⁶ 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 (pp. 88–90).

FIGURE 1: Hidden Hunger Map¹¹

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 co-exist, 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

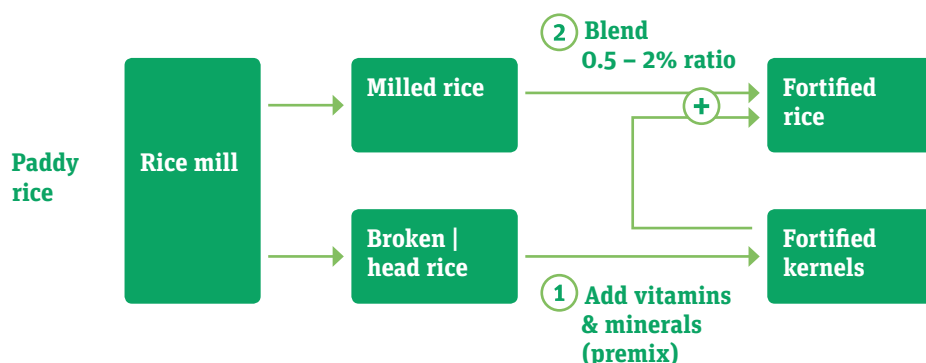
also highly prevalent.¹ **Figure 1** demonstrates the global landscape of micronutrient deficiencies, also called hidden hunger.

“Although more prevalent in LICs and MICs, micronutrient deficiencies also represent a public health problem in industrialized countries”

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.

Rice fortification builds upon the global success and long-established evidence base for safe and effective flour and salt

FIGURE 2: Two-step rice fortification manufacturing process

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. For more information on lessons to be learned from flour and salt fortification programs, please refer to the contribution by Kupka et al (pp. 68–72).

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 multi-sectoral 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”**

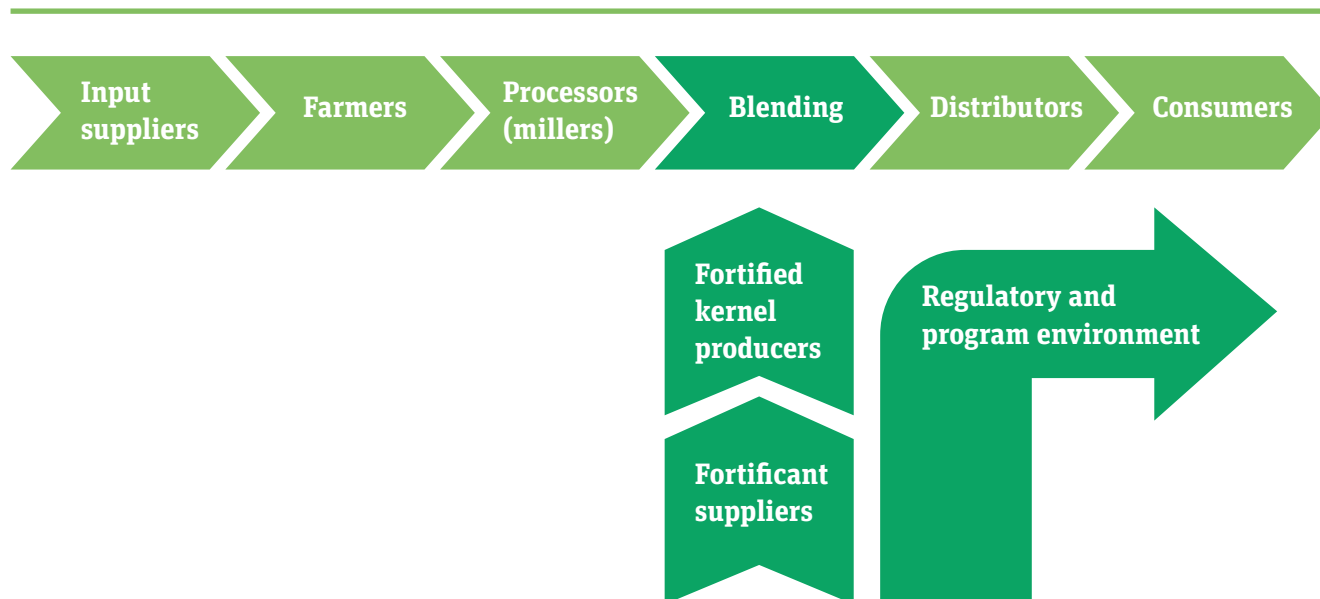
Rice fortification technology and production

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 (pp. 57–62).

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 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 additional fortification steps has to take into account the following aspects:

FIGURE 3: Rice fortification supply chain

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. For more information on conducting a rice landscape analysis, please refer to the contribution by Yusufali et al (pp. 43–49).

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 in-

terventions. For additional information on the evidence for recommended micronutrients and standards, please refer to the contributions de Pee et al (Trials, pp. 20–25 and Standards, pp. 52–56).

“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



Young girl in Myanmar tasting fortified rice

of rice. Therefore, fortified rice will not be sufficient to fill their micronutrient gap. For additional information on specific micronutrient needs across the lifecycle, please refer to **Figure 4** in the contribution by Rudert et al (pp. 31–36).

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 (pp. 73–78).

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. This approach has been applied in Bangladesh. For more information on Bangladesh's successful social safety net fortification, please refer to contribution by Ebbing et al (pp. 79–82).

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 (pp. 37–42).

“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. For additional information on rice fortification costs, please refer to the contribution by Ghos et al (pp. 63–67).

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 and beyond is vast. The time is right – there is great momen-

tum to move forward with rice fortification from a growing number of governments, private sector leaders, and key global health organizations. Asia can seize the momentum and lead the way in building effective and sustainable rice fortification programs.

References

1. Allen L, de Benoist B, Dary O et al, eds. Guidelines on food fortification with micronutrients. Geneva: World Health Organization/Food and Agriculture Organization, 2006.
2. Champagne ET, Wood DF, Juliano BO et al. The rice grain and its gross composition. In: Champagne ET, ed. Rice: Chemistry and Technology. 3rd ed. St Paul, MN, USA: American Association of Cereal Chemists, 2004; pp. 77–107.
3. Beretta Piccoli N, Grede N, de Pee S et al. Rice fortification: its potential for improving micronutrient intake and steps required for implementation at scale. *Food Nutr Bull* 2012;33(4):S360–S372.
4. Black RE, Allen LH, Bhutta ZA et al. Maternal and Child Undernutrition Study Group. Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet* 2008;371:243–260.
5. Bhutta ZA, Das JK, Rivzi A et al. Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? *Lancet* 2013;382:452–77.
6. Copenhagen Consensus 2012 available at www.copenhagenconsensus.com/copenhagen-consensus-iii. Accessed May 18, 2015.
7. Haddad L. Ending Undernutrition: Our Legacy to the Post 2015 Generation. Sussex, UK: Institute of Development Studies in partnership with the Children's Investment Fund Foundation, 2013.
8. Forsman C, Milani P, Schondebare JA et al. Rice fortification: a comparative analysis in mandated settings. *Ann N Y Acad Sci* 2014;1324:67–81.
9. de Pee S. Proposing nutrients and nutrient levels for rice fortification. *Ann N Y Acad Sci* 2014;1324:55–66.
10. Roks E. Review of the cost components of introducing industrially fortified rice. *Ann N Y Acad Sci* 2014;1324:82–91.
11. Muthayya S, Rah JH, Sugimoto JD et al. The global hidden hunger indices and maps: an advocacy tool for action. *PLoS One* 2013;8(6):e67860. doi: 10.1371/journal.pone.0067860 (adapted from source).

Highlights from Technical Consultation Meeting

Organized by WHO in Collaboration with the Global Alliance for Improved Nutrition (GAIN) for Rice Fortification in Public Health, September 2012, Geneva

Regina Moench-Pfanner

GAIN Singapore

Katrien Ghoois

World Food Programme Regional Bureau for Asia

Background

The World Health Organization (WHO) has a mandate to develop evidence-informed guidelines for the fortification of staple foods. The WHO's guidelines for rice fortification are currently in development. WHO guideline recommendations are driven by the quality of the evidence, following the highest research standards, and balanced by larger public health considerations. The WHO guidelines for rice fortification will help to ensure the effectiveness, efficacy, and safety of fortified rice.

As a key step in the guideline development, the WHO, in collaboration with the Global Alliance for Improved Nutrition (GAIN), convened a consultation on Technical Considerations for Rice Fortification in Public Health in Geneva, Switzerland, from 9 to 10 September 2012.

Meeting objectives

The objectives of the consultation meeting were to provide inputs to the rice fortification guideline development process, and to discuss technical considerations of the rice fortification process. The focus of the discussions was on the implementability and feasibility of rice fortification, as well as its potential as a public health strategy to increase the target population's micronutrient health. Discussions also included the assurance of equitable access and universal coverage.

Participants

In addition to the two convening agencies (WHO and GAIN), participants in the consultation included academia (researchers in public health and food fortification); private sector companies (rice producers/manufacturers; premix suppliers; retailers); civil society (i.e., NGOs working on food fortification); UN agencies; and donor agencies.

Consultation results

The consultation resulted in a review of:

- Different technologies used industrially for the production of fortified rice
- Worldwide rice consumption patterns
- The stability of micronutrients in fortified rice and rice products
- The bioavailability of potential iron and zinc compounds used in the fortification of rice
- The methodological approach to estimate appropriate fortification levels in different types of rice, according to technology and consumption practices
- International experiences with legal frameworks and definitions of rice fortification
- International experiences with norms and standards for fortified/enriched rice

Technical topic papers

In preparation for the consultation, background documents were commissioned by experts in food fortification and nutrition science. These papers covered a wide range of topics including: rice production and consumption; global rice industrial processing; fortification technologies; stability and retention of micronutrients in fortified rice; determinants of acceptability

and availability of fortified rice; the legal framework; estimating nutrient fortification levels; the economic feasibility; legislation and policies; quality assurance and quality control. These papers informed the rice fortification workshop held in Bangkok, Thailand in 2014.

Research gaps

Following the consultation, the technical experts identified research gaps in rice fortification evidence. The experts agreed on the following research priorities:

- To determine the stability of different micronutrients in various context-specific environments
- To study the nutrient-nutrient interaction so as to better understand relative bioavailability and phytate effect on iron absorption
- To research the optimal delivery platforms for reaching the target populations
- To study the effectiveness of different fortification methods in different contexts

Conclusion

The WHO- and GAIN-convened consultation brought together key stakeholders for input into the WHO rice fortification guidelines. The background materials (see below) were published in a special issue of the *Annals of the New York Academy of Science* (<http://tinyurl.com/lkt2yod>). In 2014, the WHO's Nutrition Guideline Group met to formulate recommendations and determine the strength (GRADE tables) for rice fortification. These recommendations are expected in the coming year.

Together with the papers in this *Sight and Life* supplement, the consultation's technical papers provide guidance for governments or agencies seeking to introduce, implement and scale up rice fortification.

Background materials from the *Annals of the New York Academy of Sciences* September 2014, Volume 1324, Technical Considerations for Rice Fortification in Public Health (pp. 1–91). Issue edited by: De-Regil LM, Laillou A, Moench-Pfanner R et al.

- De-Regil LM, Peña-Rosas JP, Laillou A et al. Considerations for rice fortification in public health: conclusions of a technical consultation (pp. 1–6)
- Muthayya S, Sugimoto JD, Montgomery S et al. An overview of global rice production, supply, trade, and consumption (pp. 7–14)
- Atungulu GG, Pan Z. Rice industrial processing worldwide and impact on macro- and micronutrient content, stability, and retention (pp. 15–28)
- Steiger G, Müller-Fischer N, Cori H et al. Fortification of rice: technologies and nutrients (pp. 29–39)
- Wieringa FT, Laillou A, Guyondet C et al. Stability and retention of micronutrients in fortified rice prepared using different cooking methods (pp. 40–47)
- Van TK, Burja K, Nga TT et al. Organoleptic qualities and acceptability of fortified rice in two Southeast Asian countries (pp. 48–54)
- de Pee S. Proposing nutrients and nutrient levels for rice fortification (pp. 55–66)
- Forsman C, Milani P, Schondebare JA et al. Rice fortification: a comparative analysis in mandated settings (pp. 67–81)
- Roks E. Review of the cost components of introducing industrially fortified rice (pp. 82–91)

Overview of Evidence and Recommendations for Effective Large-Scale Rice Fortification

Saskia de Pee

World Food Programme, Rome, Italy
Friedman School of Nutrition Science
and Policy, Tufts University, Boston

Cecilia Fabrizio, Jennifer Rosenzweig

World Food Programme Regional Bureau for Asia

Key Messages

- Multiple efficacy and effectiveness studies have established the impact of fortified rice on micronutrient status.
- To prepare for the introduction of fortified rice, countries should conduct a landscape analysis to assess feasibility and consumer acceptability. Given the existing evidence base, it is not necessary to conduct additional efficacy trials prior to the introduction of rice fortification.
- Based on available evidence of efficacy, stability and needs, the following micronutrients are recommended for rice fortification: iron, zinc, and vitamins A, B₁ (thiamin), B₃ (niacin) B₆ (pyridoxine), B₉ (folic acid) and B₁₂ (cobalamin).
- Rice fortification programs should use technology and micronutrient fortificant forms that produce fortified rice that is acceptable to consumers, retains micronutrients during storage and preparation, and releases them for absorption by the body.
- When introducing fortified rice, countries should monitor implementation. This includes appropriate fortification (i.e., of fortified kernels and their blending), storage and distribution, and monitoring of acceptance and consumption.

Introduction

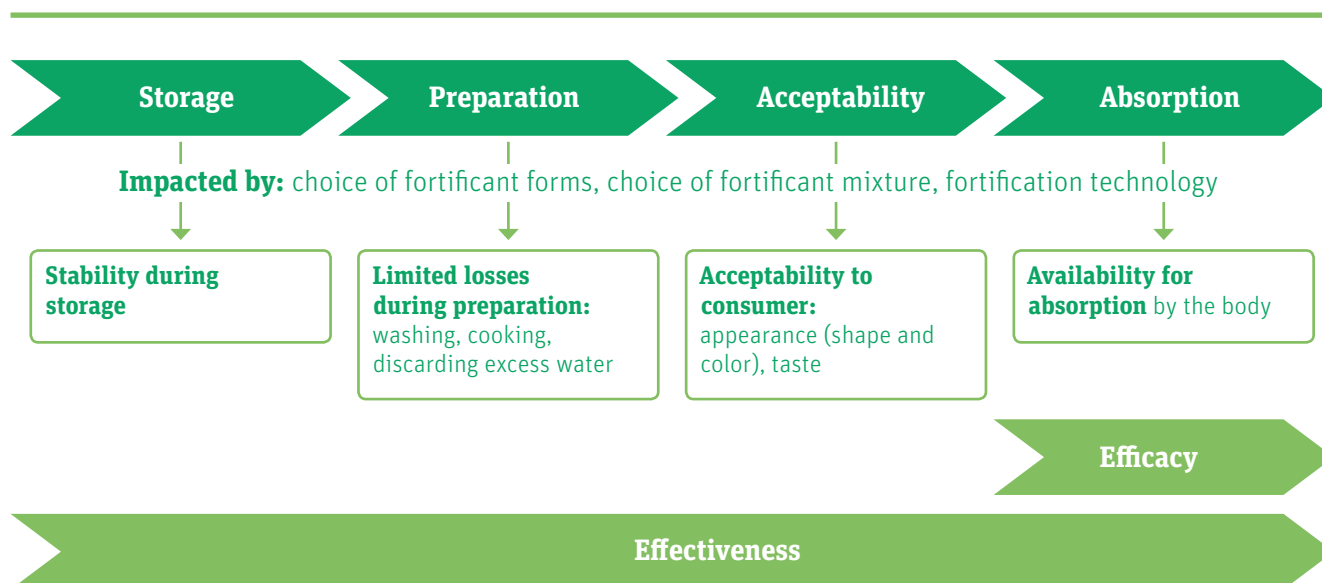
In populations where rice is a major staple food, fortification of rice with micronutrients has the potential to increase micronutrient intake. Decades-long experience with fortification of other staple foods and condiments has proven that large-scale fortification is efficacious. This article discusses country-level considerations for rice fortification and reviews the global evidence base for the efficacy and effectiveness of rice fortification.

Country-level considerations for food fortification

Identifying suitable micronutrients for fortification

An analysis of which micronutrient deficiencies are likely to exist and are of public health significance will help determine which micronutrients should be used to fortify rice, and in what form. The comprehensive publication by the World Health Organization (WHO) and the Food and Agricultural Organization of the United Nations (FAO), “Guidelines on Food Fortification with Micronutrients” assists countries in the design and implementation of appropriate food fortification programs and is particularly helpful for low- and middle-income countries.¹ The WHO/FAO publication provides guidance on the selection of food vehicles, and which micronutrients to add, in what chemical form, and in which quantities. More specific rice fortification guidelines are in development.

“An analysis of which micronutrient deficiencies are likely to exist will help determine which micronutrients should be used to fortify rice”

FIGURE 1: Factors that determine the efficacy and effectiveness of rice fortification

Requirements for rice fortification to be effective

For a rice fortification program to be effective, the following conditions need to be met:

- The micronutrients used to fortify the rice should remain stable during storage, i.e., losses over time are limited.
- The micronutrients should be retained after preparation (washing, cooking, discarding excess water).
- The fortified rice should be acceptable to the consumer in appearance (shape and color), taste and smell.
- The micronutrients remaining post-cooking should be available for absorption by the body (see **Figure 1**).

These requirements are affected by the fortificants' chemical forms and formulation, the fortification technology, and any possible interaction between micronutrients, or the rice matrix. Finally, the fortified rice needs to be consumed regularly and in the expected quantities by the desired population groups in order to make a good contribution to micronutrient intake.

Global evidence for rice fortification

The following is a review of two types of studies conducted on micronutrient fortification of rice that address the conditions illustrated in **Figure 1**. One type of study examines the *efficacy* of key micronutrients used in rice fortification. These carefully controlled studies assessed whether consumption of a given amount of rice, fortified with micronutrients in a specific concentration, using specific fortificant forms and fortification technology, resulted in the micronutrients being absorbed and utilized by the body. In *effectiveness* studies, people in specific population groups were provided with fortified rice under less controlled circumstances. The studies assessed whether these

groups – who prepared and consumed the fortified rice in their homes – showed a reduction in the signs of micronutrient deficiencies or changes in micronutrient status. Under these studies, impact on the micronutrient status of participants was also dependent on storage, preparation, acceptance, and unsupervised consumption of the fortified rice.

Efficacy studies of fortified rice

Since early 2000, thirteen efficacy studies have been published that assessed the impact of fortified rice on micronutrient status.^{2–14} All studies used fortified kernels that were produced using extrusion technology. Each study was conducted in a controlled environment, and aimed to compare impact on micronutrient status among individuals who received fortified rice, versus individuals who received non-fortified rice and/or micronutrients in supplement form. In nine of the studies, the rice was fortified only with iron, in one study only with vitamin A,¹⁴ and in three studies a combination of micronutrients was used, i.e., iron, zinc and vitamin A in the studies by Pinkaew et al,^{11,12} and iron, zinc, vitamins A, B₁, B₆ and B₁₂ and folic acid in the study by Thankachan et al.¹³ The studies were conducted in low- and middle-income countries, including the Philippines, India, Nepal, Thailand, Mexico and Brazil. Study populations included children aged 6–23 months, preschool and school-age children, women of reproductive age, and anemic individuals.

Iron results

All 12 efficacy studies on iron-fortified rice used ferric pyrophosphate (FePP) as the iron form. One study also included a group that received ferrous sulfate.¹⁰ Although FePP is not the most bioavailable iron fortificant, it has so far been the only type of

TABLE 1: Studies on iron-fortified rice

Reference	Country	Study group	Dosage	Findings
Angeles-Agdeppa I, Capanzana MV, Barba CV et al. ²	Philippines	6–9 y old anemic children	10 mg/d (2 groups: FePP and ferrous sulphate)	Hb improved, anemia declined, no change of serum ferritin
Beinner MA, Velasquez-Meléndez G, Pessoa MC et al. ³	Brazil	6–24 mo old anemic children	23.4 mg/d	Hb improved, anemia declined, serum ferritin increased, iron status improved
Hotz C, Porcayo M, Onofre G et al. ⁴	Mexico	18–49 y old women (non-pregnant, non-lactating)	20 mg/d	Hb increase non-sign. (p=0.069), plasma ferritin, transferrin receptor, and iron stores improved
Nogueira Arcanjo FP, Santos PR, Leite J et al. ⁵	Brazil	10–23 mo old children	56.4 mg/meal, one meal/wk	Hb improved, anemia declined
Nogueira Arcanjo FP, Santos PR, Segall S. ⁶	Brazil	2–5 y old children	56.4 mg/meal, one meal/wk	Hb remained the same, whereas it declined in control group
Nogueira Arcanjo FP, Santos PR, Arcanjo C. ⁷	Brazil	10–23 mo old children	56.4 mg/meal, one meal/wk	Hb improved, anemia declined
Moretti D, Zimmermann MB, Muthayya S et al. ⁸	India	6–13 y old schoolchildren	13 mg/d	Body iron stores improved (all other Hb and iron status parameters, no change)
Radhika MS, Nair KM, Kumar RH et al. ⁹	India	5–11 y old schoolchildren	19 mg/d	Hb and anemia no change, serum ferritin increased, iron deficiency reduced
Zimmermann M, Muthayya S, Moretti D et al. ¹⁰	India	5–9 y old schoolchildren	10 mg/d	Hb no change, transferrin receptor no change, serum ferritin increased, iron deficiency declined
Pinkaew S, Winichagoon P, Hurrell RF et al. ¹¹	Thailand	4–12 y old schoolchildren	12.3 mg/d	Hb and serum ferritin, no change, iron deficiency declined
Thankachan P, Rah JH, Thomas T et al. ¹³	India	6–12 y old schoolchildren	6.25 mg/d and 12.5 mg/d	Hb and iron status indicators, no change

iron identified that does not affect the color and taste of rice. Research has very recently been conducted that successfully increased the bioavailability of this type of iron (submitted for publication). The amount of fortified rice that was provided in the studies ranged from 50 g/week to 140 g/day and was often provided as one meal per day. The blending ratios of the fortified rice ranged from 0.5 to 2.5%, and the iron content of the fortified rice meal ranged from 6 to 56 mg. The studies did not report on the color of the fortified kernels or the acceptability of the fortified rice, but as feeding took place under controlled conditions, all participants were apparently willing to consume the rice. Eleven of the 12 studies with rice fortified with iron assessed impact on hemoglobin concentration or anemia. None of the studies found a negative impact, while five found an improvement. Six of the eight studies that assessed iron status found an improvement. In total, 10 of the 11 studies found a positive impact on either hemoglobin concentration or iron status, or on both (see **Table 1**). The authors of the one study that found no impact on hemoglobin concentration or iron status reported that they discovered post-study that the participants had actually received iron supplements until a few months before the study started.¹¹

These results provide strong evidence that the fortification with iron was effective. The fact that a greater proportion

of studies found an impact on iron status as compared to the proportion that found an impact on hemoglobin concentration may be due to homeostatic control (i.e., there is limited room for improvement of hemoglobin concentration among non-anemic individuals) and due to the fact that iron deficiency causes only approximately 50% of anemia. As other nutritional and non-nutritional causes also affect anemia, there are limits on the impact of iron on hemoglobin concentration.

When considering fortification of rice with iron at scale, cost and consumer acceptability are key. Blending ratio impacts cost. Color and taste, which depend on choice and level of iron fortificant, can affect consumer acceptance. These aspects were less important in the efficacy studies. With the current recommended fortificant form of micronized ferric pyrophosphate in order not to have a colored fortified kernel, the concentration of iron cannot exceed 7 g/kg. When fortified kernels are blended with normal rice at 1%, which is a commonly used ratio, the iron content of the fortified rice will be 7 mg/100 g. Most of the efficacy studies blended at a higher ratio, and some also had a higher concentration of iron in the fortified kernels. The high iron concentration in the fortified rice, and the fact that most studies provided all the iron in one meal per day, resulted in high iron content in comparison to that of

TABLE 2: Studies on vitamin A fortified rice

Reference	Country	Study group	Dosage	Findings
Pinkaew S, Wegmuller R, Wasantwisut E et al. ¹²	Thailand	8–12 y old	3,000 µg RE/d	BL* serum retinol 1.21 µmol/L – total body retinol increased – serum retinol unchanged
Pinkaew S, Winichagoon P, Hurrell RF et al. ¹¹	Thailand	4–12 y old	2,500 µg RE/d	BL serum retinol 1.01 µmol/L – No significant increase
Thankachan P, Rah JH, Thomas T et al. ¹³	India	6–12 y old	500 µg RE/d	BL serum retinol 2.1–2.6 µmol/L – No change
Haskell MJ, Pandey P, Graham JM et al. ^{3,14}	Nepal	Night-blind pregnant women	850 µg RE/d	Serum retinol increased in all groups, most in liver & high-dose capsule groups

*BL: baseline

iron absorption inhibitors. This may have had a further positive impact on iron absorption in the studies.

Vitamin A results

Four studies included rice fortified with vitamin A, three of which were also fortified with other micronutrients. The one study that fortified rice only with vitamin A was conducted among night-blind pregnant women in Nepal and provided study groups with different sources and levels of vitamin A.¹⁴ This study reported an improvement of vitamin A status in all groups, with the greatest improvement in the two groups that received vitamin A from either a high-dose capsule or liver. The other three studies were conducted among schoolchildren with an average baseline serum retinol concentration considered indicative of adequate, or close to adequate, vitamin A status^{11–13} (see **Table 2**). Their serum retinol concentration did not increase further. However, the one study that also measured total body retinol reported an improvement.¹² This evidence shows that vitamin A can effectively be added to rice. However, it is important to consider whether rice is the most appropriate vehicle. For example, where cooking oil is already adequately fortified with vitamin A, it is not also necessary to fortify rice with vitamin A.

Results with other micronutrients

The impact of fortification of rice with zinc, folic acid, vitamins B₁ (thiamin) and B₁₂ on micronutrient status has also been assessed. Thankachan et al.¹³ studied rice fortified with iron, zinc, vitamins A, B₁, B₆ and B₁₂ and folic acid. In a study by Pinkaew et al.,¹¹ impact on zinc status by rice fortified with iron, vitamin A and zinc was assessed. Thankachan et al found an improvement of vitamin B₁₂ status and a decrease of homocysteine levels.¹³ This indicated that both vitamin B₁₂ and folic acid were well absorbed and utilized. They found no change of indicators of thiamin or zinc status. Thiamin status was

already sufficient. The absence of impact of zinc fortification on serum zinc concentration, which has also been reported by other studies,¹⁵ may be due to the fact that only a small fraction of the body's zinc pool appears in serum. This makes it insensitive to modest changes of status. The study by Pinkaew and colleagues reported a decline of zinc deficiency in both the intervention and the control groups. The improvement of serum zinc was greater in the fortified rice group compared with the unfortified rice group.¹¹

Effectiveness studies – impact of rice fortification under programmatic circumstances

Four studies analyzed the effectiveness of rice fortification under less controlled, more programmatic, circumstances.^{16–19} The first study, conducted in the Philippines in 1947–49, used coated rice fortified with thiamin, niacin and iron. Results showed a substantial reduction of beriberi, a well-known consequence of thiamin deficiency, as well as a lower incidence of infant deaths in the areas that received fortified rice.¹⁹ No biochemical indicators of micronutrient status were assessed at that time. A second effectiveness study in the Philippines in 2008 provided rice fortified with iron at approximately 3–4 mg/100 g. This study found higher hemoglobin concentrations among children after the program than before, and a decline in anemia prevalence. No changes were found among mothers.¹⁷ A study conducted in Thailand between 1971 and 1975 distributed fortified rice among different age groups of children. No significant differences were found in anthropometry, hemoglobin and hematocrit between children of the villages that received the fortified rice and those that received non-fortified rice. According to the authors, caloric insufficiency was widespread and may have affected the results.¹⁸ More recently, after observing declines in neural tube defects (NTD) after the introduction of flour fortification with folic acid, Costa Rica also began fortifying rice and milk with folic

acid. Studies conducted in 2011 demonstrated further NTD declines.¹⁶

Recommended micronutrients for rice fortification

The above reviewed evidence from efficacy and effectiveness studies supports the fortification of rice with iron, vitamin A, folic acid, vitamin B₁₂ and thiamin. Zinc is also recommended, although one study found an impact on zinc status while the other one did not. These mixed findings are consistent with findings from studies on zinc fortification of other foods and may partly be due to the fact that zinc status is difficult to assess accurately.¹⁵ For niacin and vitamin B₆, data of impact on micronutrient status have not yet been collected, but adding these is recommended as well, because polished rice is a poor source of these essential micronutrients,²⁰ bioavailable forms of these nutrients exist, and adding them to rice together with the other micronutrients does not markedly increase the costs of fortified rice.

“The above evidence supports the fortification of rice with iron, vitamin A, folic acid, vitamin B₁₂ and thiamin, and the addition of zinc, niacin and vitamin B₆ is also recommended”

Research and development

Research is under way to identify more bioavailable forms of iron, which is important for safeguarding the impact on iron status under normal circumstances (see iron section above) while maintaining good consumer acceptability. Research is ongoing to compare micronutrient retention and absorption of fortified rice produced with rinse-resistant coating versus extrusion technology.

What to assess when introducing rice fortification at scale

Figure 1 shows essential components for effective rice fortification. First is the choice of the appropriate fortification technology, and identification of required micronutrients. The selected fortificants must be in efficacious forms and required amounts, and stable. Required evidence and information for this step is presented in this article, in the article on technology by Montgomery et al (see pp. 57–62), and in the paper on standards by de Pee and Fabrizio (see pp. 52–56). After technology and types of levels of fortificants have been chosen, it is very important to assess production feasibility (initially, just for blending, later also fortified kernel production), and consumer acceptability. Then the following should be put in place:

- **Quality assurance, quality control and monitoring**

Manufacturers should conduct their own quality assurance and quality control. Separately, independent monitoring should determine whether the rice is fortified as expected, i.e., the fortified kernels have the required composition and are blended at the required ratio and staying within a given range of variation. In addition, stability testing needs to be conducted under prevailing storage, preparation and cooking conditions to assure content remains adequate.

- **Monitoring of coverage, acceptability and consumption levels**

These aspects need to be monitored, and adjusted where necessary. The contribution of fortified rice to micronutrient intake depends on whether consumers obtain, accept and consume it in required quantities.

- **Monitoring of micronutrient intake, morbidity and micronutrient status**

Since rice fortification is one component of a broader strategy to address micronutrient deficiencies, monitoring should assess whether the combination of strategies is improving the health and nutritional status of different target groups in the population and/or whether additional measures may be required. Monitoring should be conducted over time, including assessment before and after implementation of the program has started at scale.

“Countries considering rice fortification do not need to conduct additional efficacy studies”

Conclusion

Multiple studies have established that with the appropriate levels of micronutrients and fortificant forms, and with effective technology, fortified rice is an effective intervention to improve micronutrient status. Countries considering rice fortification as an intervention to address micronutrient deficiencies do not need to conduct additional efficacy studies. Rather, countries should apply their resources to assess their own public health needs for micronutrient fortification and ensure close monitoring of implementation. The recommended micronutrients for rice fortification are iron, zinc, folic acid, niacin and vitamins A, B₁ (thiamin), B₆ and B₁₂, although if vitamin A is added to vegetable oil, it may not need to be added to rice. These recommendations are based on efficacy data, and the public health significance of the deficiencies of these micronutrients. In addition consideration is given to the feasibility of adding specific fortificants while maintaining consumer acceptability and stability

during storage. Countries should therefore focus on appropriate fortification (i.e., fortified kernels and their blending), storage and distribution, and monitoring acceptance and consumption (adequate quantities and by different subgroups).

References

1. Allen LH, De Benoist B, Dary, O et al. Guidelines on food fortification with micronutrients. Geneva: World Health Organization/Food and Agriculture Organization, 2006.
2. Angeles-Agdeppa I, Capanzana MV, Barba CV et al. Efficacy of iron-fortified rice in reducing anemia among schoolchildren in the Philippines. *Int J Vitam Nutr Res* 2008;78:74–86
3. Beinrer MA, Velasquez-Meléndez G, Pessoa MC et al. Iron-fortified rice is as efficacious as supplemental iron drops in infants and young children. *J Nutr* 2010;140:49–53
4. Hotz C, Porcayo M, Onofre G et al. Efficacy of iron-fortified Ultra Rice in improving the iron status of women in Mexico. *Food Nutr Bull* 2008;29:140–9
5. Nogueira Arcanjo FP, Santos PR, Leite J et al. Rice fortified with iron given weekly increases hemoglobin levels and reduces anemia in infants: a community intervention trial. *Int J Vitam Nutr Res* 2013;83(1):59–66.
6. Nogueira Arcanjo FP, Santos PR, Segall S. Ferric pyrophosphate fortified rice given once weekly does not increase hemoglobin levels in preschoolers. *J Rice Res* 2013;1(2): 1–6.
7. Nogueira Arcanjo FP, Santos PR, Arcanjo C. Use of iron-fortified rice reduces anemia in infants. *J Trop Ped* 2012;58(6): 475–480
8. Moretti D, Zimmermann MB, Muthayya S et al. Extruded rice fortified with micronized ground ferric pyrophosphate reduces iron deficiency in Indian schoolchildren: a double blind randomized controlled trial. *Am J Clin Nutr* 2006;84:822–9
9. Radhika MS, Nair KM, Kumar RH et al. Micronized ferric pyrophosphate supplied through extruded rice kernels improves body iron stores in children: a double-blind, randomized, placebo-controlled midday meal feeding trial in Indian schoolchildren. *Am J Clin Nutr* 2011;94:1202–10
10. Zimmermann M, Muthayya S, Moretti D et al. Iron fortification reduces blood lead levels in children in Bangalore, India. *Pediatrics* 2006;117(6):2014–21.
11. Pinkaew S, Winichagoon P, Hurrell RF et al. Extruded rice grains fortified with zinc, iron, and vitamin A increase zinc status of Thai school children when incorporated into a school lunch program. *J Nutr*. 2013;143(3):362–8.
12. Pinkaew S, Wegmuller R, Wasantwisut E et al. Triple-fortified rice containing vitamin A reduced marginal vitamin A deficiency and increased vitamin A liver stores in school-aged Thai Children. *J Nutr* 2014;144(4):519–24
13. Thankachan P, Rah JH, Thomas T et al. Multiple micronutrient-fortified rice affects physical performance and plasma vitamin B₁₂ and homocysteine concentrations of Indian school children. *J Nutr* 2012;142:846–52
14. Haskell MJ, Pandey P, Graham JM et al. Recovery from impaired dark adaptation in night-blind pregnant Nepali women who receive small daily doses of vitamin A as amaranth leaves, carrots, goat liver, vitamin A-fortified rice, or retinyl palmitate. *Am J Clin Nutr* 2005;81:461–71.
15. Hess SY, Brown KH. Impact of zinc fortification on zinc nutrition. *Food Nutr Bull* 2009; 30: S79–107.
16. Arguello M, Solis L. Impacto de la fortificación de alimentos con ácido fólico en los defectos del tubo neural en Costa Rica. *Rev Panam Salud Publica* 2011;30(1):1–6.
17. Angeles-Agdeppa I, Saises M, Capanzana M. Pilot-scale commercialization of iron-fortified rice: Effects on anemia status. *Food Nutr Bull* 2011;32:3–12.
18. Gershoff SN, McGandy RB, Suttapreyasri D. Nutrition studies in Thailand. II. Effects of fortification of rice with lysine, threonine, vitamin A and iron on preschool children. *Am J Clin Nutr* 1977;30:1185–95.
19. Salcedo J Jr, Bamba MD, Carrasco EO et al. Artificial enrichment of white rice as a solution to endemic beriberi; report of field trials in Bataan, Philippines. *J Nutr* 1950;42:501–23.
20. De Pee S. Proposing nutrients and nutrient levels for rice fortification. *Ann N Y Acad Sci* 2014;1324:55–66.

Addressing Myths and Misconceptions about Rice Fortification

Helena Pachón

Food Fortification Initiative and Hubert Department of Global Health, Emory University

Cecilia Fabrizio, Jennifer Rosenzweig

World Food Programme Regional Bureau for Asia

Key Messages

- Rice fortification is safe.
- Where rice is the staple food and micronutrient deficiencies are widespread, rice fortification has great potential to significantly contribute to the reduction of micronutrient deficiencies. However, on its own it cannot eliminate all micronutrient deficiencies in a population, in the most vulnerable groups, e.g., pregnant and lactating women and preschool children, additional interventions such as supplementation are required.
- Micronutrient deficiencies affect all socioeconomic groups. Therefore, where micronutrient deficiencies are widespread, rice fortification benefits all socioeconomic strata of society.
- Rice fortification and biofortification differ as to the type, number and levels of micronutrients in rice, and as to when they are included in rice. In biofortification, the process of fortifying occurs during the crop production phase, or prior to the harvest. In rice fortification, the fortification is done post-harvest and can add more types and higher levels of micronutrients.
- When fortified with multiple micronutrients, white rice is more micronutrient-rich than brown, parboiled, or non-fortified white rice.
- With a few exceptions, any variety of rice can be fortified.
- Current technologies can produce fortified rice that tastes, smells and looks the same as non-fortified rice, and retains its nutrients when prepared using various cooking methods.

Introduction

Concerns, myths, and misconceptions exist regarding the benefits and safety of rice fortification. This paper addresses these concerns by presenting information from the global experience as well as evidence based on rice and wheat flour fortification.

“The fortification of staple foods and condiments has been safely used for more than 90 years to help reduce micronutrient deficiencies”

Is rice fortification safe?

The fortification of staple foods and condiments – a strategy used for more than 90 years – has been proven safe and effective in significantly contributing to the reduction of micronutrient deficiencies. As with other food fortification, rice fortification is safe because the type and levels of micronutrients added are calculated based on the following:

- The recommended daily intake of specific micronutrients by age group and gender, as a person's age, gender and physiological status influences their daily nutrient requirements for healthy body functions
- The highest level of intake that is likely to pose no risks of adverse effects in an age and gender group, which is referred to as the tolerable upper intake level (UL) The fortification levels are chosen so that the UL is not exceeded when fortified food is consumed
- The level of specific micronutrients typically consumed by the target population
- The daily/regular quantity of rice consumed by the target population

This information is used to calculate the gap between the micronutrients consumed and the micronutrients required by specific groups. This gap is used to determine which micronutrients, and how much of the specific micronutrient, will be included in fortified rice. In other words, the level of micronutrients added is calculated such that the additional micronutrients provided in fortified rice will provide the greatest number of individuals in the target population with adequate intake, without causing intake above the UL by those who consume large quantities of the fortified rice. Fortified rice fills the micronutrient gap, without promoting excess intake.

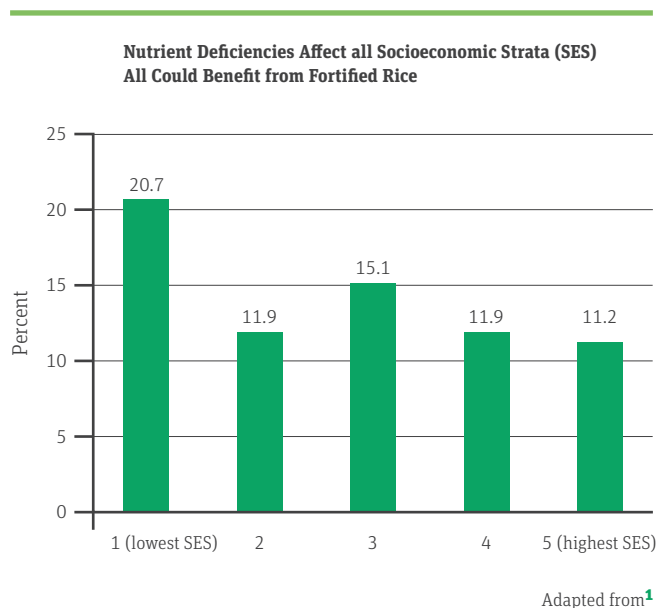
It is important to remember that:

- The type and levels of micronutrients are set in such a manner that even groups consuming large quantities of fortified rice will not exceed the UL. For example, in some countries, the typical adult consumes up to 400 or 500 g of rice per day. In this case, the micronutrients are added at a level that ensures that micronutrient intakes from all dietary sources are below the UL, taking a daily rice consumption of 400–500 g into consideration. Thus, the micronutrients consumed in fortified rice will be at a safe level.
- Specific population groups have higher micronutrient needs than others. For example, pregnant women are recommended to take iron/folate or multiple micronutrient supplements to meet their micronutrient requirements. This remains safe, and is recommended even when they are consuming fortified foods. This is because their micronutrient requirements are much higher than those of the average population. The same holds true for young children who also may be taking vitamin A or other micronutrient supplements. A young child also consumes much smaller quantities of rice than healthy adults in the same population. This, combined with their relatively high micronutrient needs, means that young children are not at risk of exceeding their UL with fortified rice.

Can rice fortification eliminate micronutrient deficiencies in the entire population?

Rice fortification can significantly contribute to the reduction of micronutrient deficiencies. For safety reasons, the fortification levels are calculated such that the additional micronutrients provided in fortified rice will provide the greatest number of individuals in the target population with adequate intake, without causing excessive intake. On its own, this level of fortification cannot eliminate all micronutrient deficiencies among all segments of the population. For example, a pregnant woman has significantly higher micronutrient needs than a man of the same age. Fortified rice can contribute to meeting the needs of pregnant women,

FIGURE 1: Percentage of non-pregnant Vietnamese women (15–49 years) with iron deficiency, by socioeconomic group.

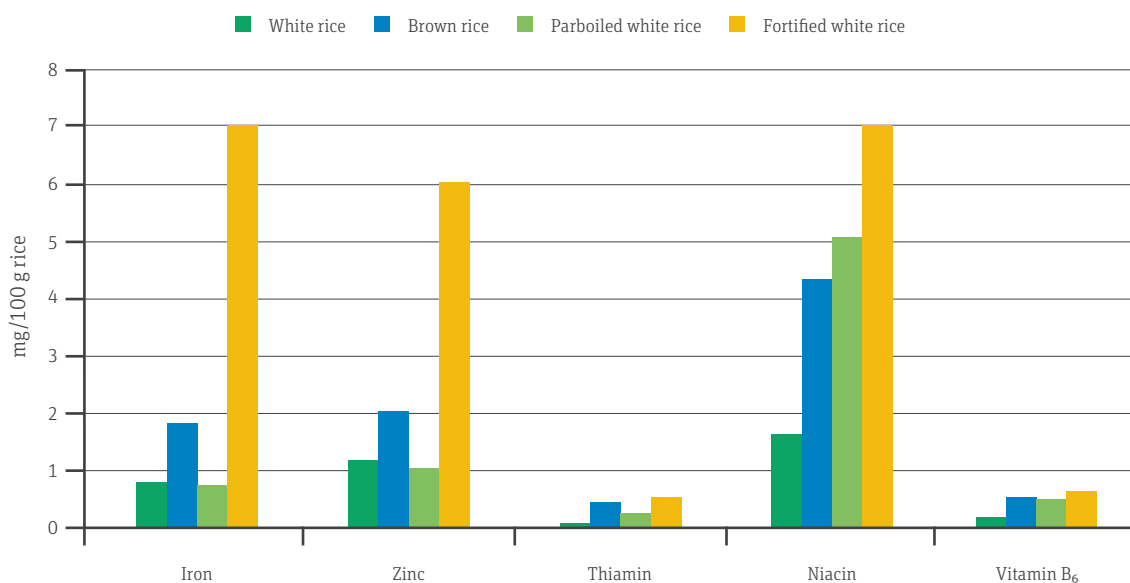


but cannot fully meet their needs. Children under the age of two years also have relatively high micronutrient needs to support their growth and development. However, they can only consume small quantities of food in comparison to adults, so the additional micronutrients received by eating fortified rice will not be sufficient to fill their gap in micronutrient intake. Therefore other simultaneous micronutrient interventions are necessary to increase the micronutrient intake of these target populations. For more information on addressing nutrition objectives, please refer to the contribution by Rudert et al (pp. 31–36).

“Fortified rice can help meet the needs of pregnant women and of young children, but cannot fully meet their needs”

Is fortified rice only needed by low-income groups?

Although micronutrient deficiencies are more prevalent among lower socioeconomic groups, deficiencies also occur in higher-income groups, urban populations, obese individuals, and individuals with higher-than-average education. For example, as shown in the 2000 Vietnamese National Nutrition Survey (see **Figure 1**), iron deficiency was highest among women from the lowest socioeconomic group (20.7%). However, at least 11% of women from higher socioeconomic groups were also iron deficient, even in the highest income group.¹ This demonstrates that fortifying rice with iron can benefit all strata of society who consume rice.

FIGURE 2: Profile of select micronutrients in white rice, brown rice, parboiled white rice, and fortified white rice.⁴

What is the difference between fortified and biofortified rice?

Rice fortification and biofortification are two different approaches to make rice more nutritious. They can safely coexist as part of a strategy to improve micronutrient health. The difference lies in when and how micronutrients are added, and the type, number and level of micronutrients that can be incorporated.²

In rice fortification, micronutrients are added after the rice has been harvested. For example, folic acid, niacin, vitamins B₁ (thiamin), B₆ (pyridoxine), B₁₂ (cobalamin), A (retinol), D (cholecalciferol), E (tocopherol), iron, zinc and selenium can be added without changing the appearance of the rice. For additional information, please refer to the contributions by de Pee et al (pp. 20–25), Montgomery et al (pp. 57–62) and Rudert et al (pp. 31–36).

Biofortification increases the micronutrient content through breeding or genetic modification (GM). Therefore it occurs *before* harvesting the crop. An example of biofortification is Golden Rice, which expresses β -carotene.³ In practice, a limited number of nutrients are increased in biofortified rice varieties at any one time, and research is ongoing to increase their levels. Currently, only non-GM rice cultivars with higher iron or zinc levels are available. Genetically modified Golden Rice containing provitamin A has not been released on the market.

In addition, the levels of nutrients that are added to rice can be much higher with fortification than with biofortification. However, once a rice variety is biofortified, no additional processes are needed after harvesting to increase nutrient levels.

Why not encourage consumption of brown rice or parboiled rice instead of fortified white rice?

White rice is widely consumed, and when fortified, can have a significantly higher micronutrient content than non-fortified rice, including brown or parboiled rice. Therefore, there is a greater potential to improve micronutrient health by fortifying white rice than from increasing consumption of brown or parboiled rice.

“When fortified, white rice can have a significantly higher micronutrient content than non-fortified brown or parboiled rice”

Figure 2 shows the micronutrient content (iron, zinc, thiamin, niacin and vitamin B₆) for non-fortified rice (white, brown and parboiled) and fortified white rice.⁴ The content of folate and vitamins A and B₁₂ are not shown because they are absent or negligible in all types of rice except fortified rice. The data demonstrates three points:

1. Milling removes much of rice’s naturally occurring nutrients
2. Parboiling retains a significant level of some nutrients
3. Brown rice is relatively iron- and zinc-rich compared to non-fortified white rice

While the nutrient content of fortified rice is dependent on the amounts added, fortified rice has the potential to offer much higher levels of key nutrients such as iron, zinc, vitamin A, folic acid and vitamin B₁₂.

In addition, the consumption of fortified white rice does not require a change in existing behaviors, as would be the case if consumption of brown or parboiled rice were to be increased. While there is little data on brown rice consumption in Asian countries, the 2009 US National Health and Nutrition Survey⁵ found that, after years of promotion, only 2.9% of children and 7.7% of adults consumed the recommended daily level of at least three whole grain ounce equivalents (which includes brown rice). This finding is in line with lessons learned from wheat flour and salt fortification to the effect that communication alone without additional behavior change activities does not increase consumption of a specific food. For more information on lessons learned from wheat flour and salt fortification, please refer to the contribution by Kupka et al (pp. 68–72).

“The acceptability of fortified rice depends on the fortification technology, the type and level of nutrients, and consumer preferences”

Can any variety of rice be fortified?

The rice fortification technology of dusting can be used to fortify all varieties of rice, although this technology is not recommended. For coating and extrusion, most varieties of rice can be fortified; however, this will require tailoring of fortified kernels ac-

cordingly. For more information on rice fortification technology, please refer to the contribution by Montgomery et al (pp. 57–62).

Is fortified rice acceptable to consumers?

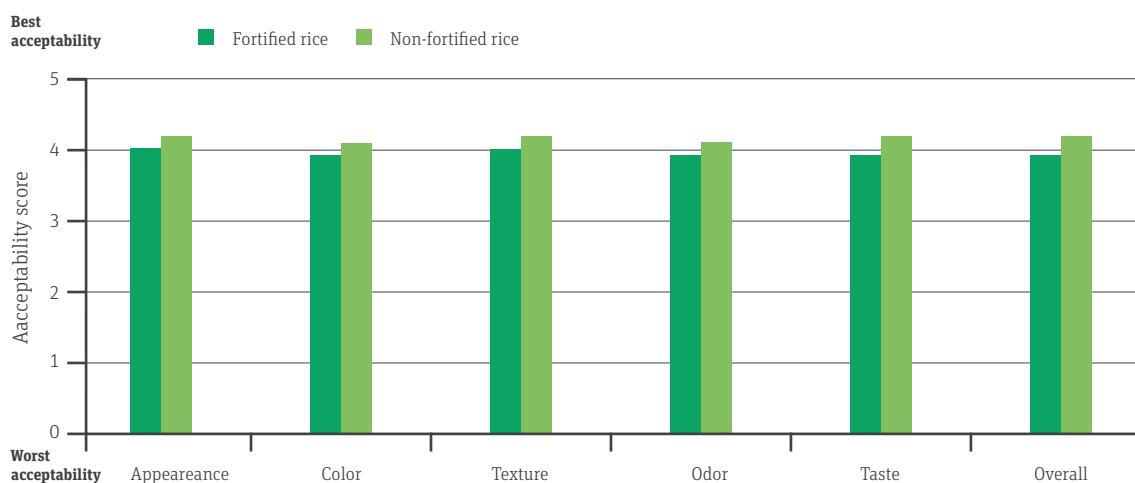
The acceptability of fortified rice depends on the fortification technology, the type and levels of nutrients added, and consumer preferences. All rice fortification technologies aim to make fortified rice taste, smell, and look the same as non-fortified rice.

A recent study that compared rice fortified using extrusion technology with non-fortified rice evaluated six sensory parameters (appearance, color, texture, odor, taste, and overall acceptability) among Indian children 8–11 years of age.⁶ The children ranked each sample with a score of 1 (worst) to 5 (best). As shown in **Figure 3**, the fortified and non-fortified rice were statistically indistinguishable on all six sensory parameters. In addition, all sensory parameters were rated over 4 points, suggesting strong acceptability for both types of rice. This study shows that consumers perceive fortified rice to taste, look, and smell similar to non-fortified rice.

Are the nutrients in fortified rice retained after preparation and cooking?

When produced using extrusion or rinse-resistant coating technologies, fortified rice will retain nutrients through various preparation and cooking conditions, including washing and cooking in excessive water that is later discarded. The micronutrients in the fortified kernels produced with extrusion technology are evenly distributed throughout the kernels. Therefore, the nutrients are adequately sealed and adequately retained through preparation and cooking. However, when fortified rice is produced using dusting or coating that is not rinse-resistant, nutrients will be lost if the rice is washed prior

FIGURE 3: Acceptability scores for fortified and non-fortified rice among Indian children aged 8–11 years.



Adapted from ⁶



Three friends eating a mid-day meal with fortified rice in a government school in Gajapati, Odisha, India

to cooking. There is ongoing additional research in this area to further identify potential differences in nutrient retention between different rice preparation and cooking methods and fortification technologies.

“Fortified rice is acceptable to consumers, as virtually any variety of rice can be fortified”

Conclusion

Fortified rice is safe and acceptable to consumers. Fortification levels are set such that the additional micronutrients consumed will provide the greatest number of individuals in the target population with adequate intake, without causing excessive intake. Fortified rice is acceptable to consumers, as virtually any variety of rice can be fortified and, if properly produced, will taste, smell and look the same as non-fortified rice. Fortified white rice may be more readily acceptable to consumers than less micronutrient-rich types of non-fortified rice, such as brown or parboiled rice. However, fortified rice should be part of a larger micronutrient intervention strategy, as population groups with higher nutrient needs, such as pregnant and

lactating women, will require additional interventions to meet their micronutrient needs.

References

1. Laillou A, Van Pham T, Tran NT et al. Micronutrient deficits are still public health issues among women and young children in Vietnam. *PLoS One* 2012;7(4): e34906. doi:10.1371/journal.pone.0034906.
2. Nestel P, Bouis HE, Meenakshi JV et al. Biofortification of staple food crops. *J Nutr* 2006;136:1064–7.
3. Ye X, Al-Babili S, Klöti A et al. Engineering the provitamin A (β -carotene) biosynthetic pathway into (carotenoid-free) rice endosperm. *Science* 2000;287:303–5.
4. USDA Nutrient Data Bank. <http://ndb.nal.usda.gov/ndb/search/list>
5. Reicks M, Jonnalagadda S, Albertson AM et al. Total dietary fiber intakes in the US population are related to whole grain consumption: results from the National Health and Nutrition Examination Survey 2009 to 2010. *Nutr Res* 2014;34(3):226–234.
6. Radhika MS, Nair KM, Kumar RH et al. Micronized ferric pyrophosphate supplied through extruded rice kernels improves body iron stores in children: a double-blind, randomized, placebo-controlled midday meal feeding trial in Indian school-children. *Am J Clin Nutr* 2011;94(5):1202–10.

Linking Rice Fortification Opportunities with Nutrition Objectives

Christiane Rudert

UNICEF East Asia Pacific Regional Office

Cecilia Fabrizio, Katrien Ghoois

World Food Programme Regional Bureau for Asia

Key Messages

- Linking rice fortification with nutrition objectives requires the identification of groups who are most at risk of micronutrient deficiencies, the groups who can most benefit from rice fortification, and the most appropriate delivery option to reach these vulnerable groups.
- In order to determine the potential impact of rice fortification, the population's micronutrient status should be assessed through a combination of available data on their biochemical micronutrient deficiency status, nutrient intake, and other proxy indicators. There is no need to conduct additional micronutrient surveys where this information is available.
- Mandatory fortification has the greatest potential to make a public health impact when it reaches the whole population. When this is not feasible, distribution of fortified rice through social safety net programs is an alternative.
- Social safety nets typically target the same population groups that can benefit most from rice fortification (e.g., school children and lower socioeconomic groups). Voluntary fortification is likely to benefit higher income groups only.
- Rice fortification cannot completely fill the micronutrient gap for groups with high micronutrient needs, such as pregnant and lactating women and young children. Additional targeted interventions remain necessary, such as iron/folate supplementation for pregnant women or micronutrient powders for young children.

Introduction

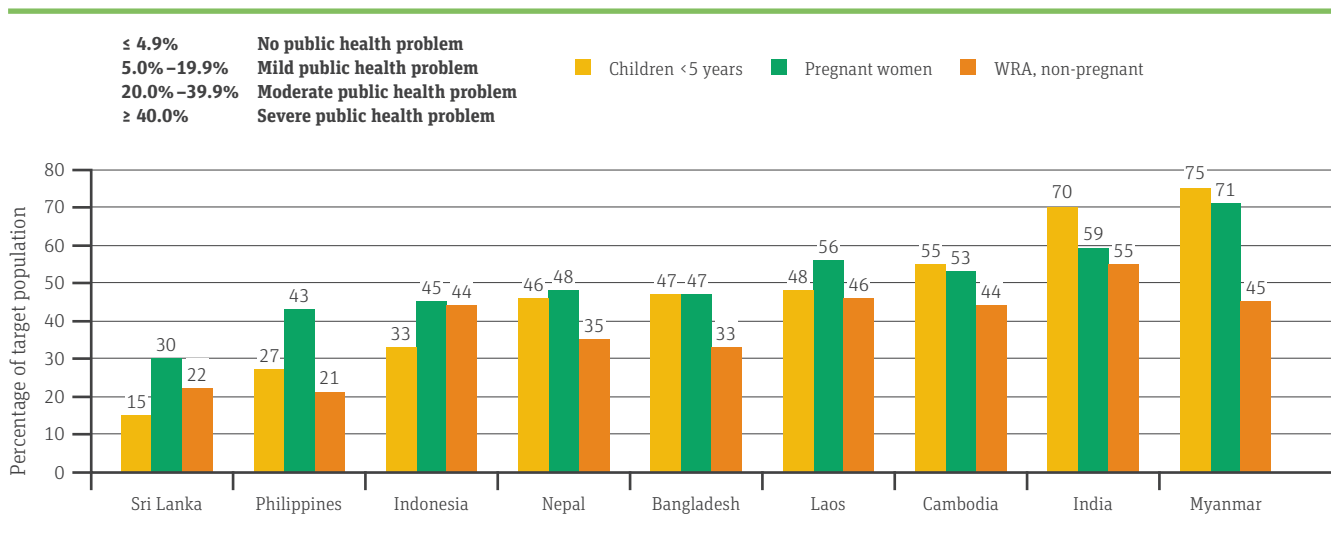
To determine the potential impact and the most appropriate delivery channel for fortified rice, it is essential to understand the population's micronutrient status, existing programs to improve micronutrient status, and the extent to which rice fortification can contribute to the micronutrient intake of the population. This article describes the process of identifying the type and level of micronutrient deficiencies in the population and the groups that are most affected. It also explains how the different delivery options may help to improve micronutrient status among identified vulnerable groups.

Importance of understanding micronutrient status

An analysis of the micronutrient deficiency situation is the first step in estimating the potential of fortified rice to improve the micronutrient status of the population.

As with all food fortification, rice fortification aims to increase a population's intake of specific micronutrients in order to reduce the proportion of that population which is at risk of micronutrient deficiencies. At the same time, fortification levels need to be set so that those who consume larger amounts of the food vehicle are unlikely to exceed the so-called tolerable upper intake level (UL). In other words, the vitamins and/or minerals added to rice should make a significant contribution to the micronutrient intake of the general population while not providing too much to individuals who consume relatively large amounts of rice. For additional information on safe micronutrient fortification of rice, please refer to the contributions of de Pee et al (pp. 52–56), Pachon et al (pp. 26–30) and Bruins in *Sight and Life* 1/2015, pp. 45–50.

“A combination of available data and proxy indicators is sufficient for estimating the burden of micronutrient deficiencies”

FIGURE 1: Prevalence of anemia in three vulnerable groups, for nine Asian countries.²

To gain a comprehensive understanding of a population's micronutrient status, it is recommended to examine data from multiple sources and methods, and where possible disaggregate by population group using factors such as socioeconomic status and geographic location, in addition to age and gender. This segmentation helps identify the target groups who can most benefit from rice fortification. The three main sources of information for obtaining a picture of the micronutrient status of a population are:

- 1) Micronutrient deficiency surveys, using biochemical data
- 2) Dietary intake of micronutrients, usually with 24-hour recall surveys
- 3) Proxy indicators, such as prevalence of anemia, stunting, neural tube defects, dietary diversity, infant and young child feeding practices, food security, and sanitation

It is important to emphasize that having complete micronutrient and nutrient intake data is NOT a prerequisite for fortification initiatives. A combination of available data and proxy indicators is sufficient for estimating the burden of micronutrient deficiencies.

“Multiple micronutrient deficiencies tend to coexist in low- and middle-income countries”

Multiple micronutrient deficiencies tend to coexist in low- and middle-income countries. The most common ones are iron, iodine, and vitamin A. These can be estimated using biochemical

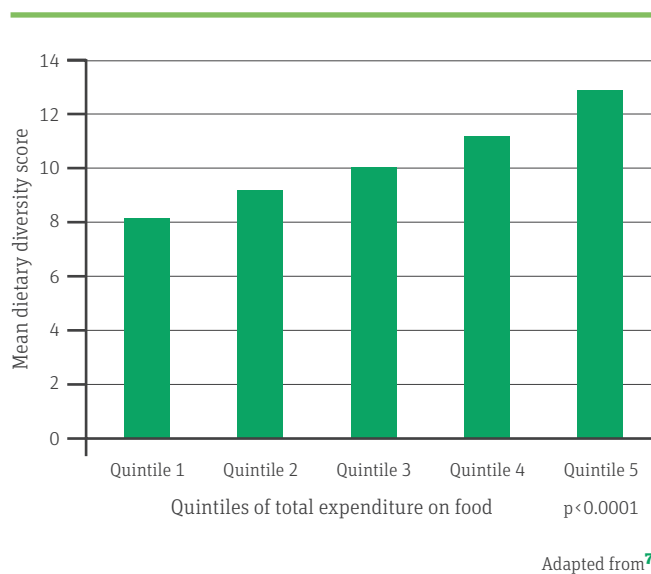
data. Zinc deficiency also makes a substantial contribution to the global burden of disease. Black et al, in the landmark 2013 Lancet Maternal and Child Nutrition series, used an analysis of national diets to estimate that 17% of the world's population is at risk of zinc deficiency.¹ This method was used as there is little biochemical data on zinc deficiency. These detectable deficiencies may also coexist with other deficiencies that are harder to detect, such as vitamin B₁₂, folic acid or vitamin D. For additional information on the global burden of micronutrient deficiencies, please refer to **Figure 1** in the contribution by Milani et al (pp. 12–17).

Micronutrient deficiency surveys can estimate a population's micronutrient status using biomarkers such as plasma retinol or retinol binding protein (RBP) for vitamin A, or ferritin to estimate iron. However, validated biomarkers do not exist for all micronutrients, and the interpretation of the results can be complex. In addition, logistics, sample collection and storage of samples may be complex. In Asia, countries with recent micronutrient surveys include Bangladesh, Cambodia, Indonesia, Nepal, the Philippines and Vietnam. Surveys in Myanmar and India are planned. Although micronutrient deficiencies primarily affect the poorest and rural populations, other socioeconomic strata and urban populations may also be affected. For additional information, please refer to **Figure 1** in the contribution by Pachon et al (pp. 26–30).

Dietary intake data

Data on foods commonly consumed by the population can supplement biochemical and clinical evidence of micronutrient deficiencies. Such data can help to identify which micronutrients are most likely to be insufficient, which population groups have insufficient diets and which areas of the country are most affected, using food composition tables indicating the micronutrient content of the foods.

FIGURE 2: Mean dietary diversity score by quintiles of total expenditure on food.



Use of proxy indicators

When nutrient intake data is not available, as is often the case in low-income countries, proxy indicators can be used to estimate the population's risk of micronutrient deficiencies. Anemia, stunting, dietary diversity and neural tube defects are most often used as proxy indicators. Additional indicators include infant and young children feeding, sanitation, and other health and food security indicators.

Anemia, commonly used as a proxy indicator for iron deficiency, has multiple causes, beyond inadequate iron or other micronutrient intake (e.g., vitamin A, folic acid, vitamin B₁₂). Anemia is most prevalent in children under five, pregnant women, and women of reproductive age. Although there is significant variation by country, it is estimated that globally only half of the anemia is caused by iron deficiency.² Non-nutritional causes of anemia include hookworm infestation, malaria, other infections, and red blood cell disorders such as thalassemia. **Figure 1** shows the high prevalence of anemia across nine Asian countries.

Stunting for children under five years of age can also be used as a proxy indicator for micronutrient deficiencies. Countries where stunting is of significant public health concern also experience significant micronutrient deficiencies, as the two public health problems share many of the same causes,³ such as inadequate nutrient intake and illness. Significant disparities exist in stunting prevalence, with children in the lowest income percentile up to three times more likely to be stunted compared to children in the highest income percentile. Rural children are up to twice as likely to be stunted compared to urban children.⁴ The disparities in stunting prevalence often mirror disparities in micronutrient status and household income levels. Neverthe-

less, in many Asian countries there are also substantial stunting rates in high-income and urban populations.

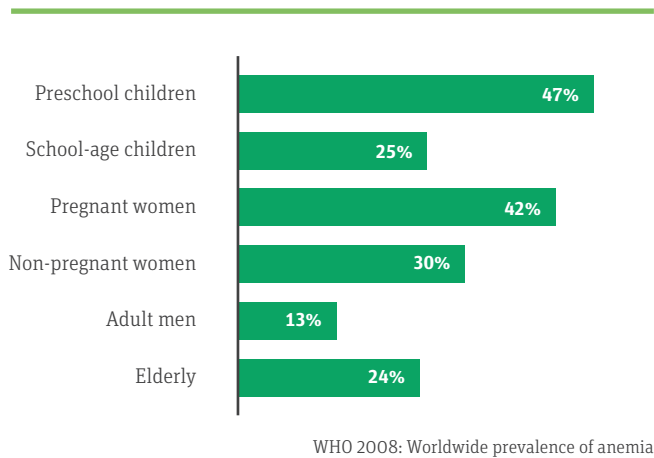
Dietary diversity is commonly used as a proxy indicator for risk of micronutrient deficiencies, as a lack of dietary diversity often results in micronutrient deficiencies. Diets lacking in diversity may have a high intake of plant-source foods and a low intake of animal-source foods, which are associated with deficiencies of key micronutrients. Cereals, roots and tubers have very low micronutrient content and/or low bioavailability (especially after milling). Monotonous diets based on these staples typically provide only a small proportion of the daily requirements for most vitamins and minerals. Fat intake, which aids absorption of fat-soluble vitamins, is also often very low with diets of poor diversity.

Animal-source foods are rich sources of protein (essential amino acids), energy, and micronutrients, including iron, pre-formed vitamin A, vitamin B₁₂, riboflavin, calcium, phosphorus and zinc.⁵ Vulnerable groups in populations with a low intake of animal-source foods are more likely to have deficiencies in some or all of these nutrients.⁵ Animal-source foods also fill multiple micronutrient gaps with smaller volumes of intake than plant-source foods. For example, to meet the daily requirements for energy, iron, or zinc, a child would need to consume 1.7–2.0 kg of maize and beans in one day. In addition, animal-source foods do not have the anti-nutritional factors that are present in plant-source foods (pulses, grains, and legumes). Anti-nutrients, or inhibitors, are natural compounds that impair the digestibility and absorption of essential nutrients. One common plant-based inhibitor is phytate, which inhibits the absorption of minerals, especially iron and zinc.⁵ Plant-based foods are often a good source of vitamin B₆, niacin and thiamin. However polishing rice markedly reduces its micronutrient content.⁶

Wealthier households tend to have more diverse diets. As shown in **Figure 2**, a study in Bangladesh found a strong correlation between household dietary diversity and socioeconomic status and expenditure on food.

Neural tube defects (NTDs) can be used as a proxy indicator for folic acid deficiency.⁸ NTDs, including spina bifida, occur when part of the neural tube, which forms the spine, spinal cord, skull and brain, fails to close between 21 and 28 days after conception – before women typically realize they are pregnant. Many children affected by neural tube defects have multiple lifelong disabilities. Women with low folate intake before and during early pregnancy are at increased risk of having babies with NTDs. It is recommended that all women of reproductive age should receive folic acid daily, which can be added to their diet through fortification or supplementation.

Other proxy indicators that can be used as indicators of risk of micronutrient deficiencies are high infection prevalence, low health service access/utilization, poor sanitation, hygiene

FIGURE 3: Prevalence of anemia in different age groups.²

and water quality, high food insecurity, proportion of household food expenditure on e.g., non-grain or animal-source foods, inadequate breastfeeding and infant and young child feeding and caring practices, etc.

Assessing the burden of micronutrient deficiencies

Although rice fortification can benefit a wide range of population groups, it is important to assess which population groups have the highest risk of micronutrient deficiency or inadequate intakes, and why. **Figure 3** shows the estimated prevalence of anemia across different population groups. The highest prevalence is estimated for preschool children with almost half of the children estimated to be anemic. In comparison, only 13% of adult men are estimated to be anemic.

“It is important to assess which population groups have the highest risk of micronutrient deficiency, and why”

Several vulnerable groups are most likely to be affected by micronutrient deficiencies:

- **Girls and women of reproductive age** are biologically more vulnerable, especially to iron deficiency, as they experience iron loss due to menstruation.
- **Pregnant and lactating women** have greater micronutrient requirements to support growth and breastfeeding.
- **Infants and young children** have greater micronutrient requirements due to rapid growth. Their relatively small stomach size also limits their intake of foods. Therefore,

their foods should be more nutrient dense than food that is consumed by older age groups.

- **Adolescents** have increased micronutrient requirements due to growth spurts.
- **Lower socioeconomic groups** tend to have a higher prevalence of deficiencies compared to higher socioeconomic groups. Typically, the diets of lower socioeconomic groups lack diversity and are primarily based on cereals, roots and tubers, with limited animal-source foods, fats and fruits and vegetables. Although the diets of poorer populations tend to be more micronutrient-deficient, the transition to energy-dense but micronutrient-poor diets with a high proportion of processed foods also puts higher-income groups at risk of micronutrient deficiencies.
- **Populations affected by emergency**, due to poor dietary diversity (mitigated to some extent when they receive fortified foods).
- **Groups marginalized** as a result of geography, ethnicity or religion.

Potential to benefit from food fortification varies across life cycle

As a population-based intervention, rice fortification must benefit those at risk of deficiencies, while remaining safe for the members of the general population that consume the most rice. To calculate the potential benefit that rice fortification can provide, the following must be assessed:

- The existing need for micronutrients, defined by the likely dietary gaps.
- The quantity of fortifiable food consumed, defined as the total amount of food consumed and the types and sources of foods that can be fortified.
- The level of fortification, where the aim is to provide enough micronutrient to reach the estimated average requirement (EAR) of adult men or women (which is approximately 70% of the recommended nutrient intake) from the fortified food, using the typical amount of the food that is consumed by adult men and women to determine the content per 100 g. For more information on calculating levels of micronutrients, please refer to the contribution by de Pee et al (pp. 20–25).

Rice fortification is one component of an integrated approach to address micronutrient deficiencies, including micronutrient supplementation (for specific target groups), promotion of dietary diversification, social protection schemes, and disease control. The potential of rice fortification to address micronutrient deficiencies varies across the life cycle. As shown in **Figure 4**, the potential for benefit from rice fortification depends on the

FIGURE 4: Potential to benefit from food fortification across the life cycle.

	Pregnancy	Lactating mother	6–23 mo	2–5 years	5–18 years	WRA (15–49 years)	Adult men	Elderly
Micro-nutrient need	very high	very high	very high	high	Moderate to high	Moderate to high	Low to moderate	Moderate to high
Amount of food eaten	moderate	moderate	low	low, increasing with age	Increases with age	moderate	high	moderate
Potential to benefit	high	high	low	low, increasing with age	Increases with age	high	high	high
Potential to fully meet need	low	low	no	low, increasing with age	Increases with age	high	high	high

needs of the target group, the amount of fortified rice the group typically consumes, the group's potential to benefit from fortified rice (dietary gap), and the potential of the fortified rice to meet the target group's micronutrient needs (filling the gap).

As shown in **Figure 4**, pregnant and lactating women have high micronutrient needs. They also have a high potential to benefit from rice fortification, because they consume a substantial amount of rice. However, despite making a good contribution, fortified rice will not be able to provide enough micronutrients to fully meet their needs. Children aged 6–23 months also have very high micronutrient needs. However, given the small quantity of rice they consume, fortified rice has a low potential to meet their micronutrient needs.

FIGURE 5: Potential public health benefit of different delivery options for fortified rice among vulnerable socioeconomic groups

Delivery option	Low income	High income	Rural	Urban
Voluntary	low	high	low	high
Mandatory	high	high	high	high
Social safety nets	high	low	high	high

“Rice fortification should be one component of an integrated approach to address micronutrient deficiencies”

Public health impact of rice fortification depends on choice of delivery option

The potential public health impact of rice fortification for specific socioeconomic population groups is dependent upon the choice of delivery options (**Figure 5**).

Mandatory fortification is generally recognized as the most effective and sustainable option. It provides more equitable access, has the potential to reach the majority of the population, and significantly helps lower the national prevalence of micronutrient deficiencies. The most vulnerable socioeconomic groups will benefit.

Voluntary fortification has significantly lower potential to reach the most vulnerable groups, such as lower socioeconomic groups and rural populations. In this market-driven approach, these groups may not be able to afford or access branded fortified rice due to higher pricing. However, voluntary fortification can help meet the nutrient requirements of some segments of the population, typically high-income groups. Experience so far has indicated that coverage remains rather low, even with high-income groups. As such, the public health impact of voluntary fortification is limited.

The distribution of fortified rice through social safety nets has great potential to reach those most at risk for micro-



Two schoolgirls eating a mid-day meal with fortified rice in a government school in Gajapati, Odisha, India

nutrient deficiencies. However, its contribution to reducing micronutrient deficiencies among the wider population depends on the proportion of the population that is reached by the social safety net.

For more information on delivery options, please refer to the contribution by Codling et al (pp. 37–42).

Conclusion

Rice fortification has the potential to contribute to the reduction of micronutrient deficiencies and positively impact public health. While all population groups may be micronutrient-deficient, the magnitude varies between groups. Additional interventions specifically targeted towards those with the highest micronutrient needs, such as pregnant and lactating women and preschool children, remain necessary.

Linking rice fortification with nutrition objectives requires the identification of groups which are most at risk of micronutrient deficiencies, the groups that will benefit the most from rice fortification, and the most appropriate delivery option to reach identified target groups. Mandatory fortification offers the greatest potential for achieving a public health impact. The fortification of rice distributed through social safety net programs provides an opportunity to reach vulnerable groups when mandatory fortification is not feasible.

References

1. Black RE, Victora CG, Walker SP et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. *The Lancet* 2013;382(9890):427–451.
2. WHO. Worldwide prevalence of anemia 1993–2005. WHO Global Database on Anemia. 2008. Accessed from: http://whqlibdoc.who.int/publications/2008/9789241596657_eng.pdf on 29 March 2015.
3. 2013 State of Food and Agriculture report: Food systems for better nutrition. Accessed at www.fao.org/publications/sofa/2013/en/ on 5 May, 2015.
4. UNICEF. Improving child nutrition: the achievable imperative for global progress. 2013. www.unicef.org/gambia/Improving_Child_Nutrition_the_achievable_imperative_for_global_progress.pdf.
5. Neumann CG, Harris D, Rogers L. Contribution of animal source foods in improving diet quality and function in children in the developing world. *Nutr Res* 2002;22:193–220.
6. Champagne ET, Wood DF, Juliano BO et al. The rice grain and its gross composition. In: Champagne ET, ed. *Rice: Chemistry and Technology*. 3rd ed. St Paul, MN, USA: American Association of Cereal Chemists, 2004, pp. 77–107.
7. Thorne-Lyman AL, Valpiani N, Sun K et al. Household dietary diversity and food expenditures are closely linked in rural Bangladesh, increasing the risk of malnutrition to the financial crisis. *J Nutr* 2010;140:182S–188S. doi:10.3945/jn.109.110809
8. Food Fortification Initiative. Fifteen Years of Fortifying With Folic Acid Reduces Birth Defects; Averts Healthcare Expenses www.ffinetwork.org/about/stay_informed/publications/documents/FolicAcidBackground.pdf.

Identifying Appropriate Delivery Options for Fortified Rice

Karen Codling

Asia Food Fortification Initiative

Cecilia Fabrizio, Jennifer Rosenzweig

World Food Programme Regional Bureau for Asia

Key Messages

- To identify the optimal delivery option for fortified rice, decision-makers should assess the public health need, the rice supply chain, the feasibility of rice fortification, and the extent and scale to which social safety nets reach groups that can most benefit from rice fortification.
- Mandatory rice fortification offers the best opportunity to maximize the public health benefit.
- When the rice milling landscape is fragmented and mandatory fortification is not feasible, the fortification of rice distributed through social safety nets is an alternative to achieve public health impact in targeted populations.

Introduction

Where rice is an important staple food, rice fortification has the potential to significantly contribute to the reduction of micronutrient deficiencies in a population. Fortified rice can reach consumers through three different delivery options. First, governments can mandate that all rice on the market be fortified. Alternatively, rice millers can voluntarily fortify rice in response to market demand. Third, fortified rice can be distributed through social safety net programs. The distribution of fortified rice through social safety net systems can occur alongside either mandatory or voluntary rice fortification. Selecting the most appropriate delivery option depends on public health need, context, and the intended objective and purpose of rice fortification.

This article provides an overview of the three potential delivery channels for fortified rice, lessons learned from implementing countries and current status of rice fortification.

“Selecting the most appropriate delivery option depends on public health need, context, and the intended objective and purpose of rice fortification”

Delivery Option 1:

Mandatory fortification

Mandatory fortification requires food producers, both of domestic and of imported food, to fortify the particular staple food or condiment with specified micronutrients. In comparison with other delivery options, experience shows that mandatory fortification has the greatest potential for public health impact (please refer to the contribution by Kupka et al for more information, pp. 68–72). This results from the consumption of the fortified food by all segments of the population, without requiring behavior change. Governments tend to institute mandatory fortification when micronutrient deficiencies, or the risk of micronutrient deficiencies, are widespread, and when a suitable food vehicle that is consumed by the majority of population can be effectively fortified.¹ Mandatory fortification requires considerable government will, advocacy, and leadership to create the necessary legislation and monitoring system.

Current status of mandatory fortification

Five low- and middle-income countries have mandatory rice fortification, but only three countries have successfully implemented programs so far, as rice fortification is still rather new (Table 1). Costa Rica has the most successful mandatory rice fortification program, with 100% of rice fortified. The country also mandates fortification of other staple foods, such as wheat and maize flours, milk, and oil, so the population's improvements in nutrient status are difficult to attribute specifically to

TABLE 1: Status of rice mandatory fortification, by country.

Country	Legislation year	Rice source, fortified kernel source & milling industry	75–149 g/d
Costa Rica	2001	40% imported; 2 domestic fortified kernel producers; 11 mills	100% fortified
Nicaragua	2009	80% rice domestically grown; 40+ mills, many small	Limited implementation
Panama	2009	40% rice imported; initial plan for government to pay for kernels	Not being implemented yet
Papua New Guinea	2007	All rice imported; fortified with imported kernels or in country of origin	At least 80% fortified (market share of largest importer)
Philippines	2001	13% imported; ~11,000 mills. Fortified kernels imported plus 3 domestic producers. SSN rice	1–2% total rice fortified 2006–2013. Currently < 1%

rice fortification. Papua New Guinea has also been successful in implementing a mandatory rice fortification program. The country's success is facilitated by the fact that almost all rice is imported rather than domestically grown. Moreover, the rice is imported by a small number of rice importers, the largest of which (with an estimated 80% market share) fortifies all its rice. Other importers in the country are believed to be fortifying at least some of their rice. The United States is the third country with mandatory rice fortification legislation. Federal legislation requires that rice must be fortified if it is produced in, goes to, or passes through, a state with mandatory legislation. Six of the US's 50 states have mandatory legislation, and have effectively leveraged their legislation so that an estimated 70% of the US rice supply is fortified.

The other three countries with mandatory fortification have struggled to operationalize and enforce rice fortification. The Philippines passed mandatory legislation in 2001 and has undertaken significant planning and investment for rice fortification, yet less than 1% of total rice is currently fortified. Initially the government put in place a work plan that projected implementation in phases, with the largest mills fortifying first. The National Food Authority (NFA), which implements a large social safety net program of subsidized rice, then conducted efficacy, effectiveness and acceptability trials of fortified rice, and purchased blenders and fortified kernels to fortify their rice at NFA warehouses. Multiple sub-national governments passed local ordinances requiring all rice to be fortified. However, despite these efforts, the private sector never started rice fortification on a large scale, primarily due to a fragmented milling industry landscape and the low fortification capacity of the thousands of small millers. There are also additional problems of technology constraints, the complexity of the supply chain for fortified kernels, and geographic logistical challenges. At this time, even the NFA rice is not being fortified, due to problems with logistics, finances and consumer uptake. As a result of these challenges, the government has not actively tried to enforce universal rice fortification.

Similarly, the governments of Nicaragua and Panama are not actively enforcing their rice fortification legislation. Again, these countries are also hampered by the high fragmentation of the rice milling industry and low industry capacity for fortification.

Lessons learned from mandatory fortification

Mandatory fortification provides the greatest opportunity for large-scale, sustainable public health impact

Although there are few mandatory rice fortification programs being implemented today, extrapolating from rice fortification efficacy studies and lessons learned from other staple food fortification (e.g., wheat flour) and condiments (e.g., salt) there is every reason to believe mandatory rice fortification would be an effective and cost-effective strategy to improve micronutrient intake. For more information, please refer to the case study on Costa Rica, in the contribution by Tacsan et al (pp. 73–78), and lessons learned from flour and salt, in Kupka et al (pp. 68–72).

Political will is necessary to establish mandatory fortification

Political will and commitment are required to pass national legislation requiring the addition of specific micronutrients to the identified food, and to set national standards. Thereafter, continued political will and government capacity are necessary to implement regulatory monitoring systems for effective enforcement of the legislation and standards.

As with all mandatory food fortification programs, mandatory rice fortification programs are only effective when enforcement is in place

Comprehensive legislation and strong enforcement create an enabling environment to ensure a sustainable and cost-effective supply of fortified rice. Legislation, once passed, must be enforced. However, generating sufficient political will, manpower, and resources to effectively enforce the legislation has been challenging in half of the countries with mandatory rice fortification legislation. Enforcement and regulation function to level the playing field and provide the private sector with

the assurance that their competitors will incur the same costs. These measures also ensure the fortification of the entire rice supply.

Mandatory fortification, including mandatory rice fortification, has minimal impact on consumer pricing

When fortified rice is mandated, consumers do not need to choose between fortified and non-fortified rice, as all the rice on the market will be fortified. Therefore, consumers do not have to change their buying habits and will not have to pay a premium price for fortified brands. In this scenario, rice millers will most probably pass on the additional costs of fortification to consumers. These costs are likely to be minimal, and will be shared across all the rice available in the market. In fact the average consumer may not notice the increased cost. In some contexts the government may choose to pay for the cost of fortification, or millers may choose to not pass on fortification costs to consumers.

The degree of industry consolidation, size, and modernization contributes to the success of rice fortification

In many rice-producing countries, rice milling has traditionally been done on a very small scale, such as one mill per village. Today, the global industry is slowly modernizing and consolidating. As demonstrated by Costa Rica, a consolidated manufacturing base facilitates the achievement of universal rice fortification. In the Philippines, the fragmented milling structure has been a significant constraint to the implementation of mandatory rice fortification legislation. This was also observed in wheat flour and salt fortification efforts. For more on the flour and salt experience, please refer to the contribution by Kupka et al (pp. 68–72).

Industry investment is necessary to develop domestic capacity for fortified kernel production

The volume of fortified kernels required to fortify a country's rice supply is considerable. Therefore, the associated transport costs of importing fortified kernels can be prohibitive. Private companies will only invest in the manufacturing facilities for fortified kernels if they are confident that national governments will enforce the legislation and that millers will comply with it. Alternatively, fortified kernel producers outside the country will only significantly increase their production capacity and be in a position to sell their products at rates that compensate for transport costs if they believe that there will be a sustained market for their fortified kernels. Millers also need to make investments in feeder and blending equipment and to purchase fortified kernels. Prior to developing domestic capacity for kernel production, players in the supply chain will need to evaluate the government's political will, manpower, and resources before committing their own resources.

Marketing, including communication for behavior change, is not necessary to influence purchasing decisions when rice fortification is mandatory

When mandatory legislation is in place and enforced, marketing and communication costs are minimal. It remains important to inform consumers that their rice is now fortified and to provide labelling that indicates the type and level of the additional nutrient content. There is no need, however, for either rice producers or the government to undertake costly marketing or other communication activities to encourage people to purchase fortified rice, as is also explained in the contribution by Kupka et al (pp. 68–72) in relation to wheat and salt fortification.

Delivery Option 2: Voluntary fortification

Fortification is voluntary when the private food industry has an option whether or not to fortify products. Voluntary fortification is a business-oriented approach, with fortified food products marketed as “value-added” products, often targeted at higher-income consumers. If millers perceive a current, potential or emerging demand for fortified rice, they may choose to develop a fortified brand to increase sales or profits. The potential for influencing a population's micronutrient health through voluntary rice fortification will be low. This is due to the uncertainty of industry uptake and consumer demand. Impact will also be limited as lower socioeconomic groups, who are most in need of fortification, are the most unlikely to purchase fortified brands due to their higher cost. Consumer aversion to changing rice preparation, cooking and eating habits, and product unavailability in typical channels, such as bulk sales, also limits the potential impact of voluntary fortification. Additionally, there is no evidence that voluntary fortification leads to mandatory fortification.

Status of voluntary fortification

Four countries have large-scale voluntary rice fortification programs, in addition to numerous other small-scale fortification efforts throughout the world. Columbia has a relatively consolidated rice industry; seven millers fortify rice and produce about 50% of the market supply. Unfortunately, Colombian millers use a coating fortification technology that is vulnerable to nutrient loss after preparation and cooking. This reduces the public health benefit. This ineffectual fortification method demonstrates that the lack of national standards is the key weakness of voluntary fortification. In Brazil and South Africa, where implementation has not been achieved at large scale (only an estimated 1–4% of rice is fortified), the rice millers are fragmented, and consumer awareness and motivation to purchase the premium-priced rice brands is low. The current status of implementation in the Dominican Republic is not known.

Lessons learned regarding voluntary rice fortification

Difficult to achieve broad public health impact

Voluntary rice fortification has not achieved high and sustained coverage of the total rice supply, except in unique situations, such as in Columbia, where industry consolidation facilitated agreement between millers to fortify. Without much coverage of the fortified product, in particular among the most poor and vulnerable populations, the health benefits will be limited. Similar lessons have been experienced with regard to wheat flour and salt iodization, as presented in the contribution by Kupka et al (pp. 68–72).

Standards are necessary, even in voluntary fortification

Voluntary rice fortification also requires appropriate standards for rice fortification. As evidence from Columbia demonstrates, the benefits of convincing millers to voluntarily fortify were offset by ineffective fortification standards. The lack of effective voluntary standards in Colombia has enabled rice producers to market fortified rice that is unlikely to provide nutritional benefit.

Government regulations and enforcement are still necessary in a voluntary system

Although the private sector determines whether to fortify, governments still have a significant role to play in setting standards and regulations for fortification. In the context of voluntary fortification, governments also have to undertake compliance monitoring and enforcement so as to ensure that fortified products meet national standards, that they are safe and correctly labeled, and that unsubstantiated health claims are not made.

Fortified rice brands are likely to be more expensive

Millers will typically raise retail prices to cover the increased costs of manufacturing and marketing fortified brands. If the fortified rice brands are being sold as value-added products, the price increase may be in excess of production and marketing costs, as producers will often position the fortified rice as a luxury product.

Increased marketing (i.e., advertising, promotion, and packaging) is needed to promote the benefits of the fortification and the premium pricing

Contrary to popular belief, marketing and social mobilization campaigns aimed at encouraging consumers to purchase fortified foods, including fortified rice, have failed to convince large segments of the population to choose fortified products. However, with voluntary fortification, consumers are offered a choice of value-added, higher-priced fortified rice or lower-priced, unfortified rice at the point of sale. Therefore, in order to increase sales of fortified products, there is no other choice than for rice producers or governments to undertake and maintain marketing and social mobilization campaigns.

Delivery Option 3:

Fortification of rice distributed through social safety nets

Targeted rice fortification can be achieved by fortifying rice distributed through social safety nets, such as school feeding programs, distributions to the poor or to vulnerable groups, food for work programs, and food aid during emergency situations. Fortifying rice distributed in social safety net programs reaches the most vulnerable populations, and thus has the potential to make a significant impact on public health. The fortification of rice distributed through social safety nets can be implemented in parallel with mandatory or voluntary fortification. It can also function as a catalyst for mandatory fortification.

Status of fortification of social safety net rice

Five countries currently distribute fortified rice through social safety net programs, which are primarily implemented by governments with funding from governments or donors. The most successful of these is the inclusion of fortified rice in the Bangladesh Government's Vulnerable Group Feeding/Development program. For more information, please refer to the Bangladesh case study in the contribution by Ebbing et al (pp. 79–82).

On a smaller scale, in Odisha state in India, the UN World Food Programme (WFP) is supporting the distribution of fortified rice with Indian-made fortified kernels blended into the non-fortified rice at the district level through the platform of the government's school feeding program. Based on the findings of the ongoing evaluation, the State government will explore expansion through the entire state's school feeding program.

In Indonesia, the RASKIN-subsidized rice program for the poor implemented a pilot program to fortify rice distributed in a limited area. Efficacy and effectiveness studies of the impact of the distributed fortified rice have been commissioned. Depending on the results, fortification may be scaled up to all RASKIN distributed rice. Ultimately, the potential impact of fortification of RASKIN rice will depend on how well the social safety net itself is functioning. It has been reported that both sub-optimal beneficiary targeting and social stigmatization resulting from the use of low-quality rice has limited effectiveness of the RASKIN program. In addition, before the pilot can be expanded, logistical challenges – such as the development of sufficient domestic capacity to produce fortified kernels and cost-effective opportunities to blend the fortified kernels with the non-fortified rice – require resolution.

In the Philippines, the National Food Authority (NFA) has enjoyed only limited success at fortifying subsidized rice. Budget constraints have limited production quantities and beneficiary coverage. In addition, the NFA purchased colored fortified kernels in order to differentiate the subsidized rice from private-market rice. As a result of this differentiation, the colored kernels have reduced the acceptability of the fortified rice among

some consumers. NFA is now considering resuming fortification with non-colored kernels, assuming that funding can be secured.

Lessons learned from fortification of rice distributed through social safety nets

Social safety net programs that include rice distribution offer a good opportunity to target fortified rice at those most in need

In situations where mandatory fortification is not possible, social safety nets may be the only delivery option for fortified rice that will achieve a public health impact. However, the public health impact will be limited to the beneficiaries of the social safety net.

Fortification of rice distributed through social safety nets can act as a catalyst for mandatory fortification

Fortification of rice in social safety nets establishes supply chains for fortified kernels and capacity for the production of fortified rice. It also provides opportunities to establish the effectiveness and acceptability of fortified rice among domestic consumers. Information on rice fortification and experience obtained through social safety net programs can increase government commitment to mandatory rice fortification.

Enforcement and regulation

The fortification of rice distributed through social safety net programs is unlikely to require national legislation, but it will require the social safety net implementer to make a policy decision and to establish or adopt a standard for fortified rice supplied in the social safety nets.

The social safety net implementer typically bears the cost of fortification

Social safety nets are often funded and implemented by the government, philanthropic organizations, or the private sector as part of their Corporate Social Responsibility activities. Rice millers and manufacturers will be invited to bid to supply the program. These private sector agents will have a guaranteed market with low risk, at a price that usually covers their increased manufacturing costs for a defined period of time. As the social safety net implementer is bearing the cost of fortification, the consumer will not be subject to a price increase.

Fortification costs may be substantial

Although the fortification manufacturing cost will be a small percentage of the price of the program, compared to the costs of procurement and distribution, the initial capital costs and reoccurring costs may still be considerable. For example, the Philippines' NFA spent over US\$1.5 million on blenders and im-

ported fortified kernels but was only able to fortify an average of 15% of the rice distributed by the program between 2006 and 2013 (an average of 160,000 metric tons per year). By contrast, in mandatory fortification programs the cost of fortification is shared by all consumers and possibly millers, in social safety net programs the cost of fortification is often borne by the program funder.

Logistical issues may impede implementation

Several of the social safety net programs have experienced logistical difficulties, such as sourcing the rice for distribution, contracting millers to blend, and sourcing fortified kernels. Challenges also exist in the implementation of the social safety net program itself, such as poor management and corruption, and ineffective and inefficient targeting. Finally, there may be consumer stigmatization as a result of participation in the program, which may be exacerbated by the use of poor-quality rice.

No marketing is needed for fortified rice in a social safety net

The fortified rice is provided to the targeted population for free or at a subsidized price; the group targeted does not have a choice regarding the brand or type of rice supplied. However, as in all fortification programs, consumers should be informed that the rice is fortified so that they understand its benefits.

Considerations for choosing the optimal delivery option

With the reliance on rice as a staple food throughout Asia and the high prevalence of micronutrient deficiencies in the region, rice should be considered as a major fortification vehicle. The impact will be maximized if high coverage of fortified rice can be achieved in those population groups with nutrient deficiencies. The choice of delivery option should be based on an analysis of the rice supply chain, an assessment of the feasibility of implementation in the given context, and identification of the target group.

Mandatory rice fortification offers the best opportunity to reach the majority of people in a cost-effective and sustainable way. However, mandatory fortification is only possible under certain conditions. Mapping the rice supply chain helps to assess the feasibility of mandatory rice fortification and should include an assessment of the proportion of rice that is milled in mills with fortification capacity, the extent of milling consolidation, the availability of warehouses where it might be fortified, and the most sustainable and cost-effective sources of fortified kernels. If the analysis suggests mandatory rice fortification is feasible, information on the rice supply chain should be used to plan implementation. For more information on analyzing the rice landscape, please refer to the contribution by Yusufali et al (pp. 43–49), and the accompanying infographic (pp. 50–51).



Cambodian schoolchildren are served fortified rice for breakfast by a local elder

Depending on the manufacturing and regulatory landscapes, voluntary fortification rarely achieves high population coverage, and is unlikely to achieve a public health impact for the most vulnerable. Therefore, in places where mandatory rice fortification is not feasible, social safety nets that distribute rice offer a good opportunity for reaching the most vulnerable. Planners must analyze the feasibility of integrating fortification into the rice procurement, processing, and distribution process of the social safety net program and estimate funding and quality assurance monitoring requirements. The efficacy and effectiveness of the fortified rice is dependent on how well the social safety net functions.

Conclusions

Mandatory rice fortification offers the best means of achieving high coverage of a population, and hence a public health benefit. Past experience shows that voluntary rice fortification has only achieved high coverage in unique circumstances, such as in Columbia, where industry consolidation facilitated agreement between millers. Social safety net programs that distribute rice are an excellent way of reaching vulnerable groups with fortified rice, and they provide valuable manufacturing and distribution experience. Importantly, assessment of the feasibility of implementation is necessary for both mandatory and social safety net delivery options. A rice landscape analysis will provide essential information to assess feasibility.

References

1. Allen L, de Benoist B, Dary O et al, eds. Guidelines on food fortification with micronutrients. Geneva: World Health Organization/Food and Agriculture Organization, 2006.

Landscape Analysis for Rice Fortification

Rizwan Yusufali

Global Alliance for Improved Nutrition

Katrien Ghoois, Jennifer Rosenzweig

World Food Programme Regional Bureau for Asia

Key Messages

- To achieve the full potential of rice fortification as a cost-effective intervention for addressing widespread micronutrient deficiencies, it must be feasible to fortify a large proportion of the rice supply, especially the rice which is consumed by the target populations who can most benefit from its consumption.
- Feasibility and sustainability of rice fortification is influenced by: the rice milling industry's structure and technical capacity; the rice market's size and extent of consolidation; the policy and regulatory environment; political will; and private- and public-sector support.
- Prior to the introduction of rice fortification, a rice landscape analysis should be conducted to assess factors which will influence feasibility, sustainability, and potential public health impact through fortification.
- A rice landscape analysis can be used to determine: how to integrate fortified kernel production and blending into the rice supply chain; the most appropriate delivery options; which stakeholders to engage; and how to adapt the regulatory and policy environment.

Introduction

Rice fortification can have a significant public health impact in contexts where rice is a staple food and micronutrient deficiencies are widespread. To realize this potential it must be feasible to fortify a large proportion, if not all, of the rice consumed. It is especially important to fortify the rice consumed by the populations who can most benefit from its consumption. For additional information on target populations and impact, please refer to the contribution by Rudert et al (pp. 31–36).

The feasibility and sustainability of rice fortification is dependent on the structure and capacity of the rice milling industry, the available distribution channels, rice consumption patterns, consumer preferences, market size, rice supply chain, and the policy and regulatory environment.¹ Therefore it is recommended that a rice landscape analysis be conducted as a means to assess factors that influence the feasibility, sustainability and impact of rice fortification.

This article presents an overview of the enabling factors for large-scale rice fortification, and suggests different components of a rice landscape analysis. It concludes with a discussion of options for the integration of rice fortification into different supply chain scenarios.

Enabling factors for achieving public health impact through rice fortification

In a multi-country review of rice fortification programs, several enabling factors were identified for large-scale rice fortification: those that enhance market attractiveness, and those that influence the ease of implementation.²

- **Market attractiveness** for rice fortification is defined as the extent to which there is: adequate per capita rice consumption, widespread micronutrient deficiencies, a supportive policy environment, and sufficient market size for fortified rice. The existence of government-sponsored or -managed social safety nets can provide such a large-size market.
- **Ease of implementation** is defined by: the level of consumer awareness and acceptance of fortified rice, adequate and cost-effective technology, adequate capacity in the rice processing industry, level of rice industry consolidation, the policy environment, the degree of restriction on rice trade, the existence of regulatory mechanisms or an institutional framework for fortification of other foods, the overall ease of doing business, and public- and private-sector support.

Adaptation of the rice supply chain to integrate fortification

Rice fortification is a two-step process during which fortified kernels are produced and blended with non-fortified rice.



Rice fields in Myanmar

When fortification is introduced, the existing rice supply chain must incorporate these two additional steps, as well as integrating regulatory monitoring.

Purpose of conducting a rice landscape analysis

A rice landscape analysis provides decision-makers with a comprehensive understanding of the factors that influence the feasibility and sustainability of rice fortification as an intervention to improve a population's micronutrient health. To introduce, implement and scale up rice fortification, strategic decisions must be made, and actions taken, within government, the private sector, and civil society. This includes: the determination of the most appropriate delivery options; how to integrate the fortification steps into the rice supply chain; and how to adapt or improve relevant policies, and regulatory and institutional frameworks. The analysis should also estimate the potential costs of fortified rice production and the impact of the fortification on public health, and should identify the key stakeholders that need to be involved.

Areas of inquiry for landscape analysis

Conducting a rice landscape analysis entails the collection and analysis of data and information on the structure of the rice

industry, existing rice distribution channels (including social safety nets that distribute rice), consumer preferences for rice purchasing and consumption, and the relevant policy and regulatory frameworks. A description of why it is important to map these factors is given below.

“A rice landscape analysis provides decision-makers with an understanding of the factors that influence the feasibility and sustainability of rice fortification”

Industry structure

The rice industry, including its infrastructure and milling capacity, is a determining factor in deciding on the location and scale of fortified kernel production and blending, the level of investment required for fortification start-up, quality assurance and quality control mechanisms, and the regulatory environment for rice fortification.¹

The ease of implementation and the potential impact of food fortification are greater in a consolidated market. For example,

the rapid centralization of the rice processing industry in Central and South America makes it conducive to implementation of national-scale rice fortification. The current trend in Asia towards modernization of the rice industry and optimization of the rice value chain will also improve opportunities for sustainable, large-scale rice fortification. Importantly, as described below in the supply chain scenarios, solutions for rice fortification exist even in non-consolidated markets.

Thus, the landscape analysis should consider the *number of rice mills, their production capacities, the market share of medium and large mills, and the geographic locations of the mills*.³ (The suggested categories for mills according to size are as follows: small mills are mills with below 1–2 t/h capacity; medium-sized mills, with capacity between 2 and 5 t/h; and large mills, with greater than 5 t/h capacity). With the current blending equipment, only the rice processed by medium-sized and large mills can be fortified. In addition, the means by which individual millers are organized is an important consideration. Functioning miller associations or other alliances can be leveraged to mobilize commitment to fortification, compliance with regulations, and capacity building. Miller associations can help mobilize commitment to regulatory compliance, and to more efficiently engaging with multiple millers.

Source of rice

The landscape analysis should assess the *geographic sources of rice, and its quantity, type, price and seasonal variability*. Most rice-consuming countries are able to meet most or all of their demand through domestic production. Other countries rely on imports to complement their domestic rice supply. Especially in larger countries, specific provinces or regions may function as suppliers to the rest of the country. Where rice is primarily imported to meet consumer demand, it may be more cost-effective to import fortified rice, or to blend non-fortified rice with fortified kernels upon arrival in the country. Countries with a large domestic supply will most likely find that domestic fortified kernel production and local blending solutions are more cost-effective.⁴

“The landscape analysis should assess the geographic sources of rice, and its quantity, type, price and seasonal variability”

Distribution and consumption of rice

It is critical to understand *existing distribution channels – that is, how rice moves from producers to consumers, as well*

as the purchasing and consumption preferences of consumers. This information is important for assessing which rice can be cost-effectively and sustainably fortified and which population groups and geographic regions can be reached, depending on the chosen delivery option. The analysis should include a reliable estimation of the number and size of wholesalers and traders, distribution routes, and the price of rice at different distribution stages.

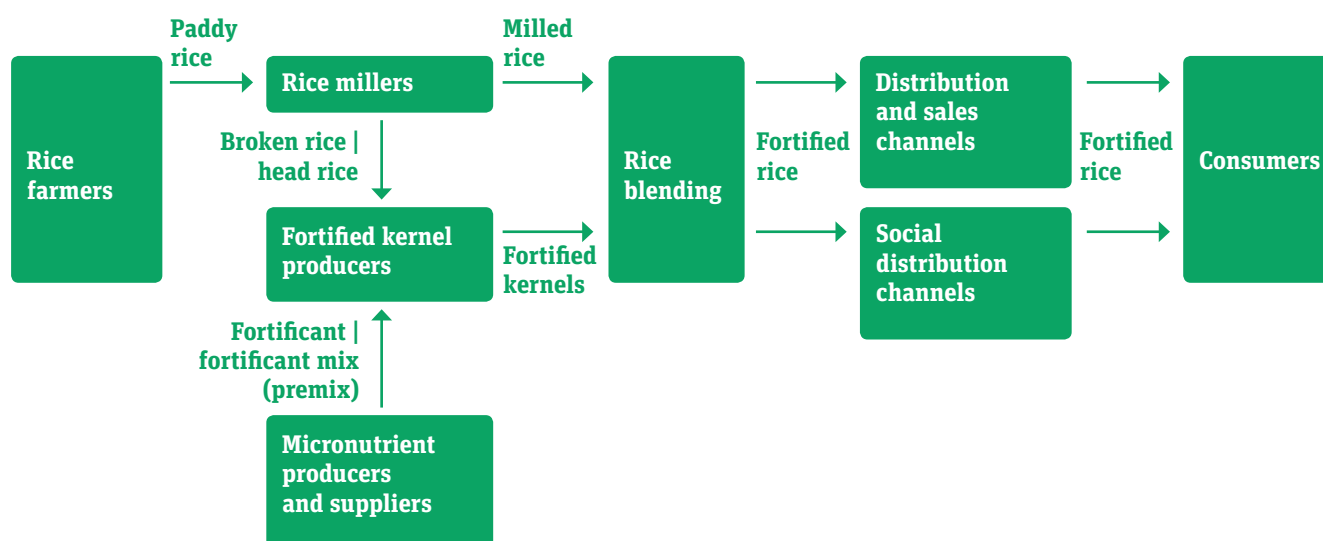
The analysis should also assess where consumers obtain or purchase their rice. What percentage is bought in local markets, how much is bought in bulk or packaged form, and how much of the rice is branded? What varieties of rice are purchased, and by which groups? How much of the rice consumed comes from an individual's own farm? Are there seasonal variations in rice purchases and consumption? How do purchasing and consumption preferences vary by geography, socioeconomic groups, or other distinguishing population characteristics?

The landscape analysis should also assess *existing social safety nets, the number and type of beneficiaries reached, the existence, size and location of warehouses, the quantity and type of rice purchased, and existing distribution methods*.

Social safety nets that distribute rice provide a potential distribution channel to reach target populations who are most likely to benefit from the consumption of fortified rice. For example, the rice provided through government school feeding programs can be fortified to reach schoolchildren that have a relatively high micronutrient need in order to sustain their growth rate and cognitive development. As is the case in Bangladesh and Indonesia, large-scale government programs distribute subsidized rice to low-income groups that are at high risk of micronutrient deficiencies, and who thus can benefit greatly from the consumption of fortified rice. For additional information on the Bangladesh social safety net system and the distribution of fortified rice, please refer to the contribution by Ebbing et al (pp. 79–82). For more information on fortification of rice distributed through social safety nets, please refer to Codling et al (pp. 37–42). For additional information on target populations that can benefit most from fortified rice, please refer to Rudert et al (pp. 31–36).

Policy and regulatory framework

An understanding of the policy and regulatory environment is important for the identification of potential barriers to the introduction of fortified rice. These may include: existing fortification legislation, regulations and standards, and national or sub-national strategies to address micronutrient deficiencies. In addition, existing commercial and trade agreements and regulations related to rice – such as import tariffs and controls, rice subsidies, and other regulations – should be assessed.

FIGURE 1: Fortified rice supply chain: detailed breakdown

Opportunities for rice fortification under different supply chain scenarios

As shown on page 15 in **Figure 3**, when rice fortification is introduced, fortified kernel production and blending must be integrated into the existing supply chain. Globally, rice supply chains differ in their level of consolidation, the number of rice millers, the degree of modernization, the role of traders and wholesalers, the types of distribution channels, and the extent of regulations.¹ **Figure 1** provides a more detailed overview of the supply chain for fortified rice.

The following is a presentation of four potential scenarios. Each scenario describes how the fortification steps can be in-

tegrated into the rice supply chain in differing contexts. The scenarios presented here are not an exhaustive list, nor are they mutually exclusive. Rather, the intent is to illustrate how the results of the landscape analysis can be utilized to develop solutions for integrating rice fortification into the rice supply chain within different contexts.

Scenario 1 | Figure 2

Consolidated milling sector with large rice mills with high individual mill production volumes

In a consolidated supply scenario with large mills having high individual production volumes, fortified kernel production and

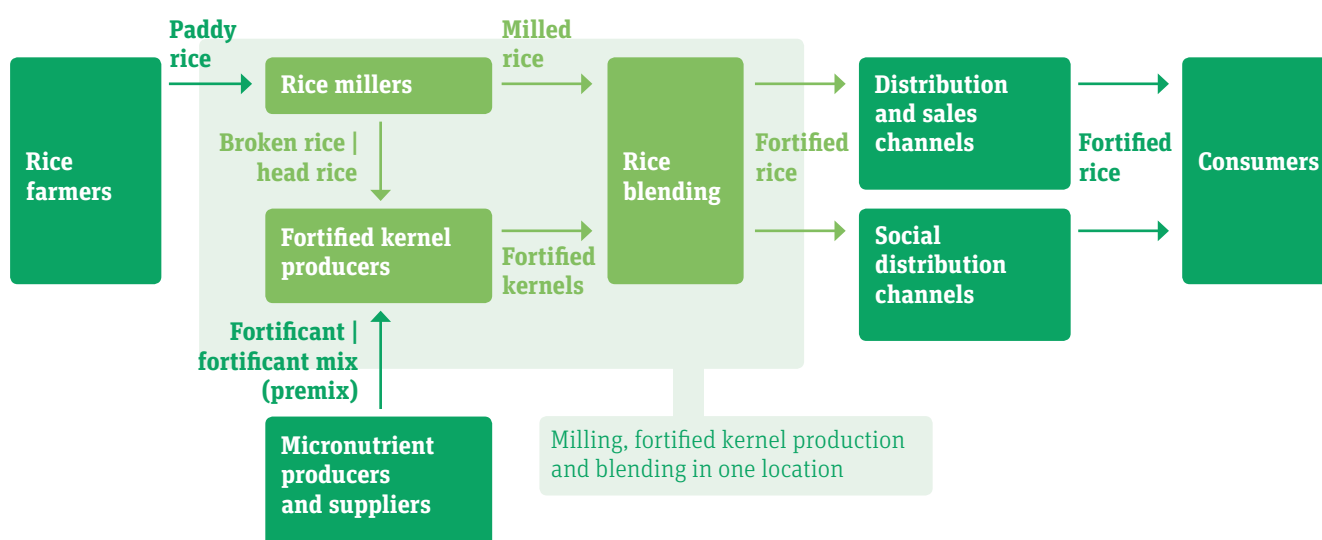
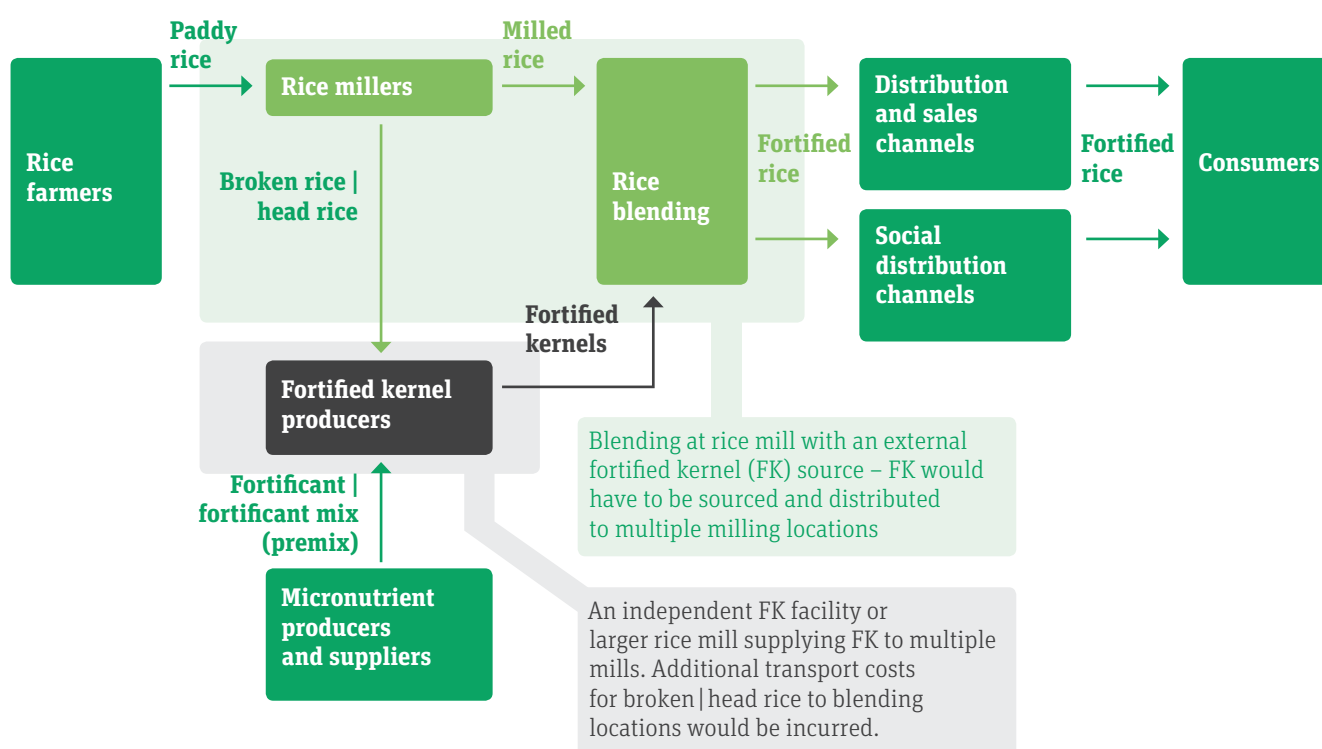
FIGURE 2 | SCENARIO 1: Consolidated milling sector with large rice mills with high individual mill production volumes

FIGURE 3 | SCENARIO 2: Large number of rice mills with medium- or large-sized milling volumes at multiple locations

blending can occur at the rice milling facilities. In this scenario, large rice millers make the initial capital investments needed to produce the fortified kernels. In some cases, the initial investment will be reduced by the availability of appropriate equipment. The rice millers are responsible for sourcing the fortificant mix and other raw materials. Ideally, they should use their own

supply of broken or head rice as raw material for the fortified kernel production.

In this integrated scenario, there is strong potential for high cost efficiency given the use of only one location for both fortified kernel production and blending. It is expected that compliance with legal frameworks will be facilitated by existing

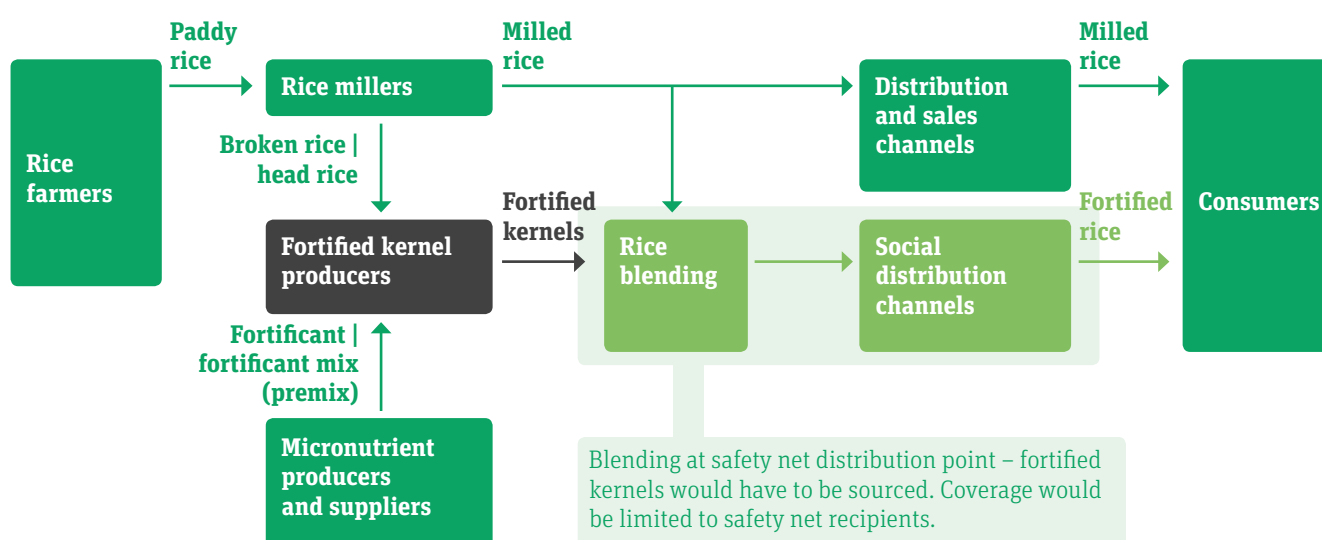
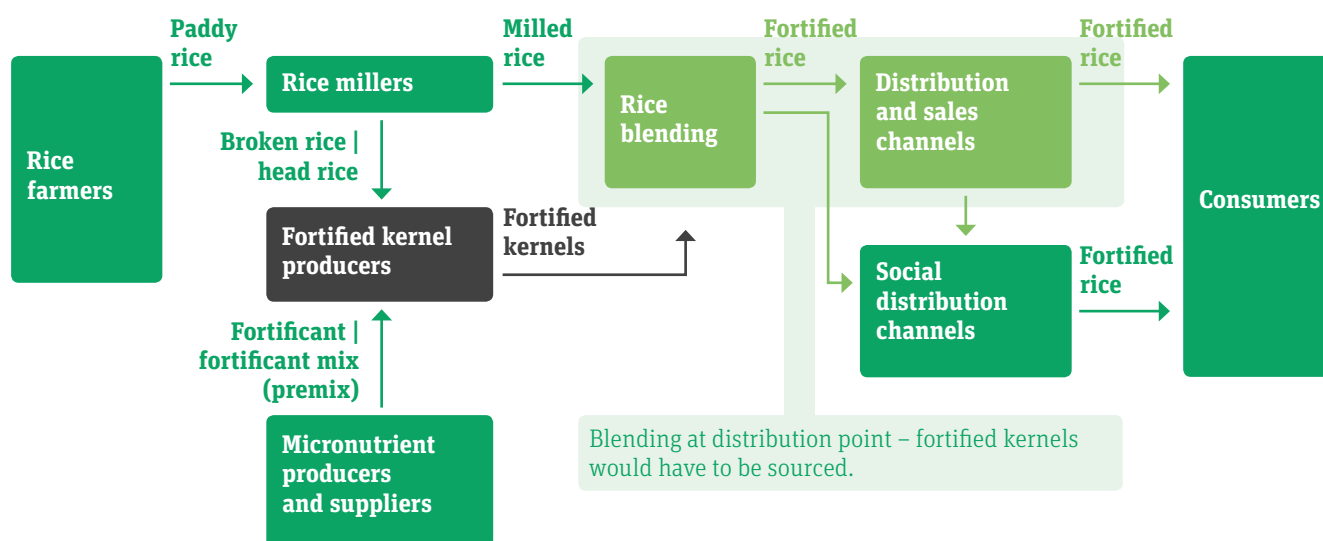
FIGURE 4 | SCENARIO 3: Existence of social safety net programs

FIGURE 5 | SCENARIO 4: Small number of distributors who consolidate milled rice supply

internal quality and safety procedures. There will be few fortified kernel production and blending sites, thus local authorities will be able to manage compliance monitoring. Also, large mills are likely to have the capital necessary to invest in the required quality assurance and quality control systems for kernel production and blending specifications.

In a slightly different scenario, fortified kernel production can become an additional revenue source for large millers who supply fortified kernels to other large and/or medium size rice mills. Yet there is a risk that the market becomes distorted as a result of the large mills that are producing fortified kernels and perform the blending, which will have a price advantage compared to the large and medium-sized rice mills purchasing the fortified kernels from the competing large rice mills. Thus, government regulations (e.g., price setting) and controls are necessary to address this issue.

What is most likely is that other food companies – for example, pasta producers or others with food extrusion equipment – will produce fortified kernels. In this case, fortified kernel producers are not rice millers and most likely do not perform the blending step. The fortified kernel producers sell the fortified kernels to blenders, and need to source rice flour or head rice as raw material. Sourcing fortified kernels from multiple manufacturers who are not involved in rice milling may be a more attractive option, since this reduces the risk of artificial price escalation and anti-competitive behavior.

Scenario 2 | Figure 3

Large number of rice mills with medium- or large-sized milling volumes at multiple locations

Medium- and large-sized rice mills can incorporate blending

facilities relatively easily. They can source fortified kernels and blend at the specified ratio with non-fortified rice. For many medium- and large-sized mills, it will not be cost-effective to invest in the production of fortified kernels. Therefore, in a situation with multiple medium- and large-sized millers, the fortified kernels will most likely be sourced from domestic producers or else imported from international suppliers. The decision as to whether to rely on domestic production or importation of fortified kernels depends in part on domestic production of rice, the market size for fortified rice, industry capacity, transportation costs, and the existing regulatory framework.

In this scenario, the rice mills performing the blending will need to ensure homogeneous blending at the correct rate as part of their quality assurance (QA) and quality control (QC) procedures. The burden of the conformity assessment of the fortified kernels' nutritional profile lies with the kernel manufacturers. Thus, basic traceability protocols, as well as the use of certificates of analysis from the fortified kernel supplier, together with third party audits, will be needed to assure the quality and safety of the final product.

In a fragmented milling landscape, common across rice producing countries in Asia, there are logistical as well as QA and QC challenges to establishing national rice fortification programs. Often the blending step is a potential bottleneck in the supply chain.

As is the case with other scenarios, it is essential to secure sufficient resources for regulatory monitoring and enforcement. (Homogeneity of blending needs to be monitored at the blending site. A regulatory standard is necessary to assure that the nutritional profile and the quality and safety attributes in the certificate of analysis are met.)

Scenario 3 | Figure 4**Existence of social safety net programs**

Social safety nets that distribute rice often target the same groups that are most likely to benefit most from rice fortification, including schoolchildren and lower socio-economic groups. Therefore these programs provide a potential distribution channel for fortified rice to reach those who can most benefit from it. For more information on delivery options, including through the social safety net, please refer to the contribution by Codling et al (pp. 37–42).

Rice distributed through social safety nets is often stored in a warehouse prior to distribution. Blending of the fortified kernels with non-fortified rice can be done at the storage warehouse. Alternatively, blending can be done by the rice millers responsible for supplying social safety net programs. Depending on the product specifications and the quantity of rice to be distributed, fortified kernels may be sourced domestically or else imported. The level of consolidation of the rice industry is of less importance in this scenario.

Scenario 4 | Figure 5**Existence of a small number of distributors with a relatively large market share**

In this scenario, it is recommended that the consolidated rice be blended with fortified kernels at a consolidation point in the supply chain. For example, if rice from many mills is consolidated at a wholesaler or trader, then the fortified kernels can be blended with the non-fortified rice before the rice is transported to the retailers. The fortified kernels can be sourced from an external supplier (local or imported).

“A rice landscape analysis informs decisions on integration of the two fortification steps (production of the fortified kernel and blending) into the existing supply chain”

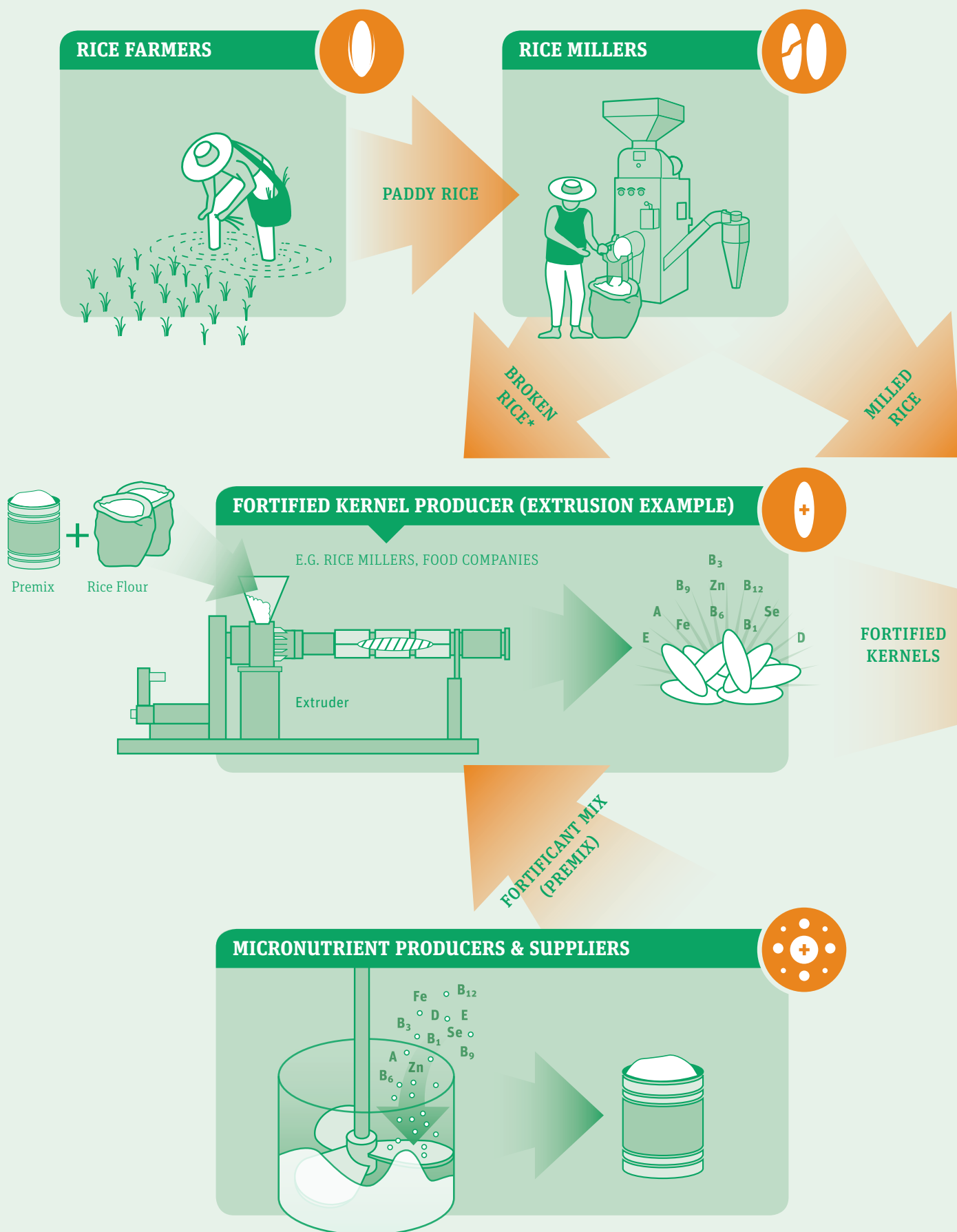
Conclusion

A rice landscape analysis provides the information necessary for strategic decision-making on how to introduce, implement and scale up rice fortification. The landscape analysis provides decision-makers with a comprehensive understanding of the rice industry, the source and availability of rice, existing distribution channels, consumer practices and preferences, and the policy and regulatory environment. This information informs decisions on integration of the two fortification steps (production of the fortified kernel and blending) into the existing supply chain, including: technology choice and regulatory monitoring, the most appropriate delivery options for fortified rice, which stakeholders to engage, and how to adapt the regulatory and policy environment. These decisions also strongly influence the potential scale and impact of rice fortification.

References

1. Forsman C, Milani P, Schondebare JA et al. Rice fortification: a comparative analysis in mandated settings. *Ann N Y Acad Sci* 2014; 1324:67–81.
2. Piccoli NB, Grede N, de Pee S et al. Rice fortification: its potential for improving micronutrient intake and steps required for implementation at scale. *Food Nutr Bull* 2012;33:360S–372S.
3. Alavi S, Bugusu B, Cramer G et al. Rice fortification in developing countries: a critical review of the technical and economic feasibility. Washington DC: Institute of Food Technologists, 2008.
4. Steiger G, Müller-Fischer N, Cori H et al. Fortification of rice: technologies and nutrients. *Ann N Y Acad Sci* 2014;1324:29–39.

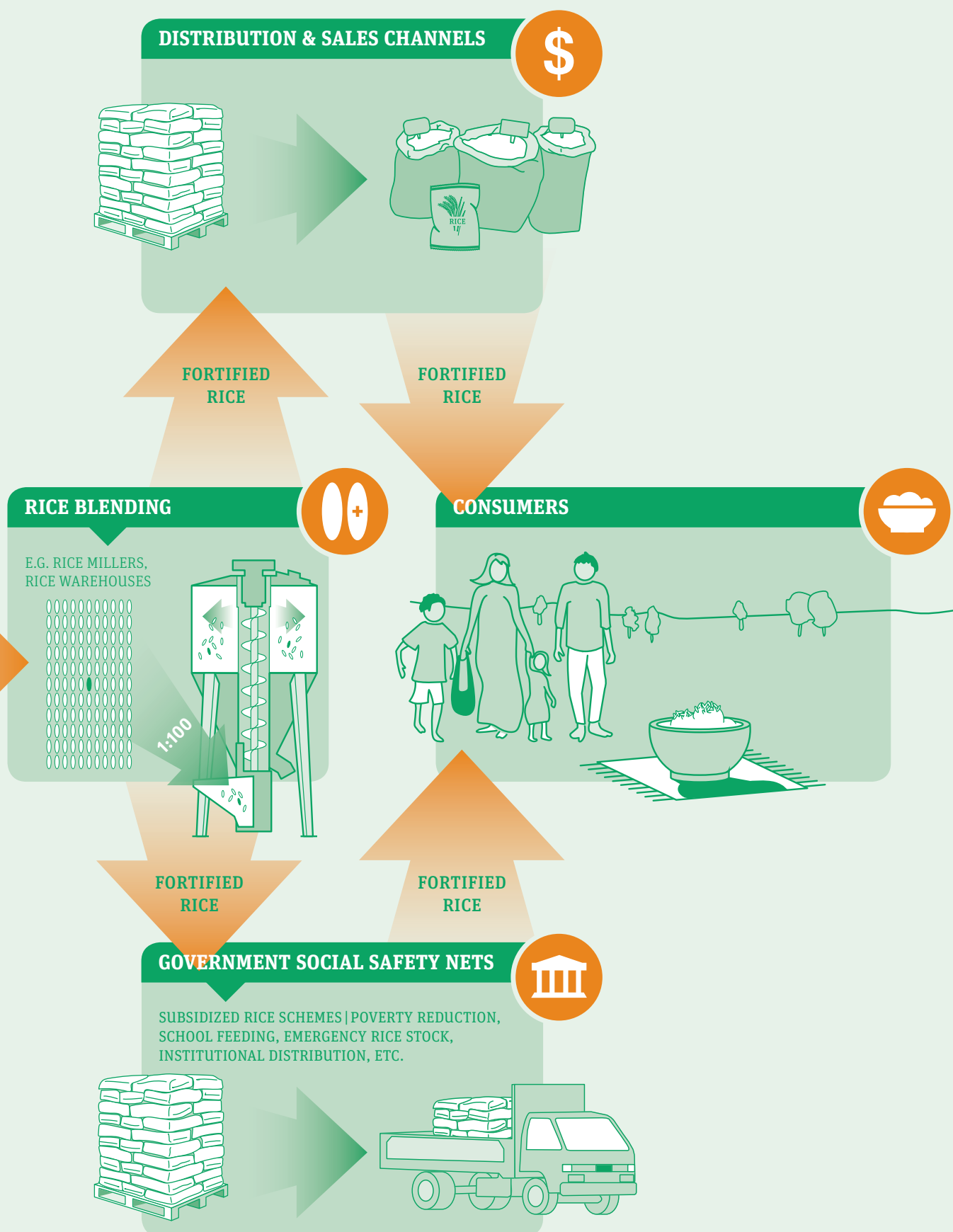
FORTIFIED RICE



* For extrusion technology broken rice can be used to produce fortified kernels; with coating technology, head rice is required.

SUPPLY CHAIN

51



TERMINOLOGY **Paddy rice:** Rice kernels still enclosed in an inedible, protective hull (rough rice) **Head rice:** Unbroken grains of milled rice with the hull, bran, and germ removed **Milled rice:** polished rice is the regular-milled white rice. Hull, bran layer and germ have been removed. **Blending:** Mixing milled, non-fortified rice with fortified kernels in ratios between 0.5–2% to produce fortified rice. **Fortificant mix:** blend that contains several selected micronutrient (also referred to as premix) **Fortified kernels:** fortified rice-shaped kernels containing the fortificant mix (extrusion) or whole rice kernels coated with a fortificant mix (coating).

Standards and Specifications for Fortified Rice

Saskia de Pee

World Food Programme, Rome, Italy
Friedman School of Nutrition Science
and Policy, Tufts University, Boston, MA, USA

Cecilia Fabrizio

World Food Programme Regional Bureau for Asia

Key Messages

- Standards and specifications for fortified rice should specify quality in terms of safety, acceptability and nutrient content, for the benefit of consumers and manufacturers.
- Drafting standards and specifications should be a consultative process.
- Codex Alimentarius provides global standards for rice and for food fortification.
- Micronutrient levels should be set such that the intake of the micronutrient in the general population, from all sources, is above the estimated average requirement (EAR) and below the tolerable upper limit (UL) for almost everyone.
- Where intake is not well known and dietary deficiencies are likely, setting the micronutrient level of fortified rice such that, at prevailing consumption levels, it provides the EAR for adults is a good approach.^{1,2}

Introduction

When a country chooses to fortify rice to increase micronutrient intake across the population, standards that specify the required quality and nutrient content provide clarity and protection for both manufacturers and consumers. These standards help ensure the nutritional quality of the rice and that the rice

is safe and acceptable for consumption. Standards are more general than specifications or Commodity Requirement Documents (CRD). For example, fortified rice standards might cover a range in terms of the types of rice, nutrient content and quality specifications. Specifications for rice for a contract, such as from a government for distribution under a social safety net scheme, are more specific, including, for example, the type of rice, the quality in terms of percentage of broken kernels that can be included, the micronutrient content to be met, the technology/ies used to produce fortified kernels, the blending ratio of fortified kernels to rice grains, the required packaging, the limits for foreign matter and heavy metals, and the shelf-life.

“Standards that specify the required quality and nutrient content for fortified rice provide clarity and protection for both manufacturers and consumers”

This paper discusses standards and specifications that exist or are being developed for fortified rice, and how to set the desired micronutrient content of fortified rice.

Codex Alimentarius standards

The global source for food standards is the Codex Alimentarius Commission (www.codexalimentarius.org), established by the Food and Agriculture Organization of the United Nations and the World Health Organization (WHO) in 1963. This Commission develops harmonized international food standards, guidelines, and codes of practice to protect the health of the consumers and ensure fair trade practices. The Commission also promotes coordination of all food standards work undertaken by international governmental and non-governmental organizations. While the adoption of Codex recommendations is

voluntary for countries, Codex standards are often the basis for national legislation.

For fortified rice, two Codex documents can be referenced: the Codex standard for rice (Codex stan 198-1995³) and the guideline for the addition of essential nutrients to foods (CAC/GL 09-1987, amended in 1989 and 1991⁴), which governs fortification of foods in general. There is no Codex standard or guideline specifically for fortified rice; nor is there a guideline specifically for other fortified staple foods. Countries should decide whether to have the same structure, i.e. a standard for rice and a standard for food fortification, and then develop specifications for individual fortified foods, such as fortified rice, that are for a particular use or for particular contracts. These specifications can include more details (e.g., micronutrient content for specific target groups, packaging specifications, etc.) and can be modified more easily when required. Standards and specifications should be developed through a consultative process that includes public- and private-sector partners, academia and civil society. Countries that have developed a standard for fortified rice include Costa Rica, the Philippines and the USA.

“Standards and specifications should be developed through a consultative process”

Setting the micronutrient content

The level of micronutrients for fortified rice should be determined after consideration of four country-specific conditions.⁵

- **First:** the consumption levels of the food in the target population: if average consumption is high, as in most rice-consuming countries, lower amounts of micronutrients are needed per kilogram of rice to achieve a target level of micronutrient intake.
- **Second:** whether other foods are fortified and with which nutrients: for example, if vegetable oil or sugar are adequately fortified with vitamin A and these foods are consumed by the same people who will consume fortified rice, vitamin A may be included at a lower level in the fortified rice, or not at all.
- **Third:** whether the food, and the diet in general, contains compounds that may affect stability or absorption of minerals or vitamins that are added, such as the phytate in grains that inhibits mineral absorption (e.g., iron and zinc); this information affects the form and level of the nutrient to be added for fortification (e.g., sodium iron EDTA is the only recommended form of iron for fortification of high extraction flour).⁶
- **Fourth:** consumer acceptability: the micronutrient fortification levels and technology used to produce the fortified kernels should be such that the rice is acceptable to the consumer in terms of appearance (color and shape), smell and taste, both before and after preparation.

If rice will be the only food fortified with the specific micronutrient(s), the level of the micronutrient should be set to provide approximately the estimated average requirement (EAR) of the micronutrient(s) for healthy adults. The EAR is the average (median) daily nutrient intake level estimated to meet the needs of half the healthy individuals in a particular age and gender group. The EAR is used to derive the recommended nutrient intake (RNI). The RNI, established by FAO/WHO, is set at the EAR plus two standard deviations, which means that it would meet the needs of 97.5% of all normal, healthy individuals in an age- and sex-specific population group (see **Figure 1**).

Most people already consume some amount of the specific micronutrients. Therefore, setting the micronutrient contribution from the fortified food at the EAR level shifts the average micronutrient intake to a level above the EAR and likely just above the RNI (see **Figure 2**). The proportion of people below the EAR should be less than 2.5% of the population, to minimize the proportion of people that do not receive adequate amounts of the micronutrient to meet their needs.

The fortified rice should make a good contribution to intake for most consumers and at the same time be safe for those who have the highest rice intake. To assess the risk of too high an intake, one has to refer to the tolerable upper limit (UL). The UL is defined as the daily nutrient intake level that is considered to pose no risk of adverse health effects to almost all (97.5%) healthy individuals in an age- and sex-specific population group. The UL applies to daily intake over a prolonged period of time, and to healthy individuals with no micronutrient deficits to be corrected. The UL includes a large safety margin as it is set at a much lower level than the lowest level at which an adverse effect of a chronically high intake has been observed.

Note that the level at which acute toxicity may occur is well above the UL level. Furthermore, as the UL is well above the RNI, and rice will be fortified at a level to provide the EAR, which is approximately 70% of the RNI, one would have to consume several times the expected daily amount of fortified rice in order to reach the UL. Thus, if 300 g of uncooked rice provides the EAR, only consumption of approximately 1–10 kg (depending on the micronutrient) of uncooked rice daily over a prolonged period of time could potentially put the consumer at risk of too high an intake from consuming fortified rice (consistently going over the UL). This scenario is unrealistic.

Determining the micronutrient level per 100 g of fortified rice that is required for the total fortified rice intake to provide

FIGURE 1: Normal distribution of nutrient needs, where 50% of the population meets their requirements at the level of the estimated average requirement (EAR) and 97.5% meets requirements at the level of the recommended nutrient intake (RNI).

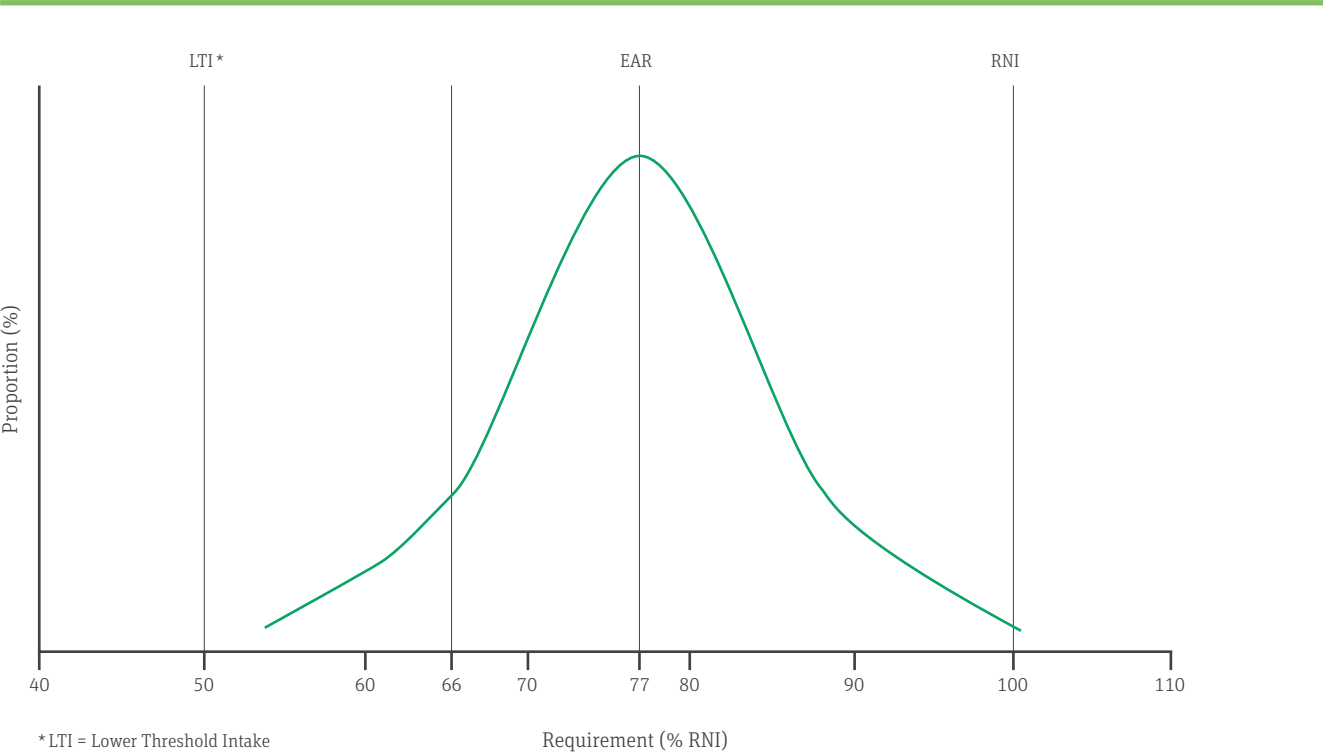
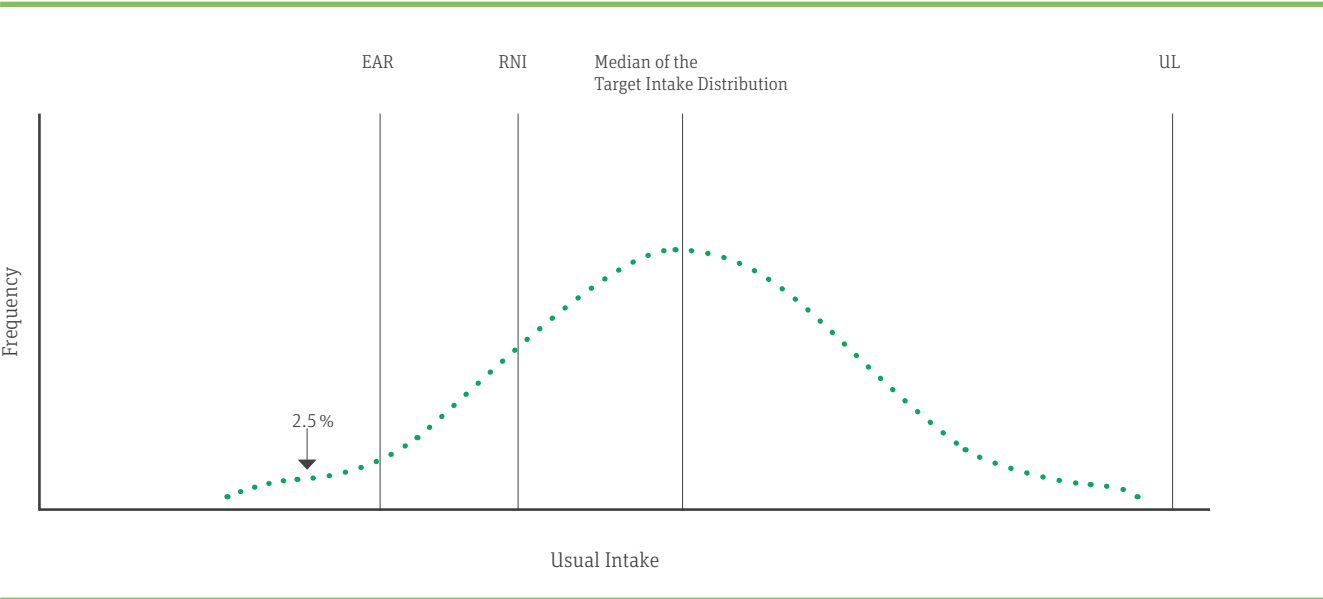


FIGURE 2: The target for micronutrient intake distribution, where 2.5% or less is below the EAR and the majority is above the RNI but below the tolerable upper limit (UL).



the EAR requires an estimate of the per capita rice consumption. For example, the EAR for vitamin B₁ (thiamin) is 0.9 mg for adult women and 1.0 mg for adult men. This means that the amount of fortified rice consumed in a day should provide approximately 0.9–1.0 mg of thiamin. The interim consensus statement on flour fortification proposed the following categories for flour consumption: < 75 g/d, 75–149 g/d, 150–300 g/d, and > 300 g/d.⁶ The same categories have been adopted for rice consumption. In countries where rice is the main staple food, average per capita rice consumption typically falls into the higher categories. In the case of thiamin, a level of 0.5 mg/100 g is proposed for the category of 150–300 g/d and 0.35 for > 300 g/d, as

ries for flour consumption: < 75 g/d, 75–149 g/d, 150–300 g/d, and > 300 g/d.⁶ The same categories have been adopted for rice consumption. In countries where rice is the main staple food, average per capita rice consumption typically falls into the higher categories. In the case of thiamin, a level of 0.5 mg/100 g is proposed for the category of 150–300 g/d and 0.35 for > 300 g/d, as

TABLE 1: Nutrient levels proposed for fortified rice at moment of consumption²

Nutrient	Compound	<75 g/d	75–149 g/d	150–300 g/d	>300 g/d	EAR
Iron	Micronized ferric pyrophosphate	12	12	7	7	
Folic acid	Folic acid	0.50	0.26	0.13	0.10	0.192
Vitamin B ₁₂	Cyanocobalamin	0.004	0.002	0.001	0.0008	0.002
Vitamin A	Vitamin A palmitate	0.59	0.3	0.15	0.1	0.357 (f) 0.429 (m)
Zinc	Zinc oxide	9.5	8	6	5	8.2 (f) 11.7 (m)
Thiamin	Thiamin mononitrate	2.0	1.0	0.5	0.35	0.9 (f) 1.0 (m)
Niacin	Niacin amide	26	13	7	4	11 (f) 12 (m)
Vitamin B ₆	Pyridoxine hydrochloride	2.4	1.2	0.6	0.4	1.1

Source: Steiger G, Muller-Fischer N, Cori H et al. Fortification of rice: technologies and nutrients. *Ann N Y Acad Sci* 2014;1324:29–39.

these would provide approximately 1.0 mg of thiamin per day at a consumption of 200 g (200 x 0.5/100 g) or 300 g (300 x 0.35/100 g), respectively.

Nutrients and nutrient levels for rice fortification have been recommended based upon this consideration of the EAR and average per capita rice consumption (**Table 1**). For more information on the rationale for choice of the eight recommended micronutrients for fortification of rice, please refer to the contribution by de Pee et al (pp. 20–25) and de Pee² (note that research conducted after the paper by de Pee was published has found a possible way of increasing iron bio-availability in rice so that lower levels may be included of approx. 4 mg/100 g instead of 7 mg/100 g in the 150–300 and > 300 g/d categories).

As mentioned above, when there are already other good sources of specific micronutrients consumed by a population, such as vitamin A fortified vegetable oil, or parboiled rice which has higher levels of thiamin, niacin and vitamin B₆ than polished rice, the levels proposed in **Table 1** should be adjusted to meet that population's specific needs. In the case of fortified vegetable oil, the average intake level of vitamin A can be calculated from the per capita consumption of vegetable oil and its fortification level. For example, if the vegetable oil provides 50% of the target EAR, the remaining 50% could be added to rice.

Table 1 and the above explanation have specified levels of micronutrients at the moment of consumption. However, as losses may occur over time, i.e., during storage, and during processing and preparation, an overage may be added at the moment of production, especially for vitamins that are heat-sensitive. Vitamin A is the most heat-sensitive and will require

more overage, while other nutrients are more stable. In addition, since there will be variation around the amount of micronutrients that are in the premix and in the fortified kernels, the blending ratio, and the laboratory measurements, specifications for fortified rice also need to specify a minimum–maximum range at the moment of production. Finally, specifications should also specify the allowed minimum content by the best-before date (i.e., the end of the rice's shelf-life).

“Rice fortification should be part of an integrated strategy for improving micronutrient intake and status of a population”

Introducing fortified rice among other fortified foods

Rice fortification should be part of an integrated strategy for improving micronutrient intake and status of a population. Therefore, as mentioned above, when there are other fortified foods, the fortification and consumption levels of those and of other main sources of the specific micronutrients need to be taken into consideration when setting the micronutrient fortification levels for rice. A program such as the Intake Monitoring, Assessment and Planning Program (IMAPP)⁷ can assist in calculating safe intake levels of the proposed micronutrients. The program integrates data on the intake of specific foods and additional supplementation among specific target groups, using a food frequency method and a 24-hour recall method.

Conclusion

Standards for a specific category of foods (e.g., rice or food fortification in general) and specifications for a specific food (e.g., fortified rice that the government will buy for the social safety net program) aim to protect the health of consumers and to provide for fair trade practices for those in the rice supply chain. These standards and specifications define quality, in terms of what is safe (e.g., foreign matter), acceptable (e.g., maximum proportion of broken kernels), and nutritious (nutrient content). Standards and specifications should be clear, without the need for further interpretation, and should also be feasible to achieve, monitor, and enforce. Experience demonstrates that standards and specifications are best developed through a consultative process, led by a government's food regulatory authority, informed by Codex Alimentarius & data, and supported by expert groups. This article has reviewed the rationale for the proposed nutrient levels for fortified rice, which can be used as is, or else adapted to a specific country context, taking existing food fortification and micronutrient intake levels into account.

References

1. Allen L, de Benoist B, Dary O et al, eds. Guidelines on food fortification with micronutrients. Geneva: World Health Organization/Food and Agriculture Organization, 2006.
2. De Pee S. Proposing nutrients and nutrient levels for rice fortification. *Ann N Y Acad Sci* 2014;1324:55–66.
3. Codex standard for rice (www.justice.gov.md/file/Centrul%20de%20armonizare%20a%20legislatiei/Baza%20de%20date/Materiale%202013/Legislatie/CODEX%20STAN%20198-1995.pdf)
4. General principles for the addition of essential nutrients to foods. *Cac/gl 09-1987* (amended 1989, 1991) (www.codexalimentarius.org/download/standards/299/CXG_009e.pdf)
5. Food Fortification Initiative: Standards. www.ffinetwork.org/plan/standards.html
6. WHO, FAO, UNICEF, GAIN, MI & FFI. Recommendations on wheat and maize flour fortification. Meeting Report: Interim Consensus Statement. Geneva: World Health Organization, 2009 (www.who.int/nutrition/publications/micronutrients/wheat_maize_fort.pdf, accessed [2 September 2014]).
7. Intake Monitoring and Assessment Planning Program (www.side.stat.iastate.edu/)

Technology for Rice Fortification

Scott Montgomery

Food Fortification Initiative

Jennifer Rosenzweig, Judith Smit

World Food Programme Regional Bureau for Asia

Key Messages

- Rice fortification using either extrusion or coating technologies is a two-step process. The first involves the production of fortified kernels; the second, the blending of fortified kernels with non-fortified rice.
- Extrusion and rinse-resistant coating are the best available technologies to produce fortified kernels that remain stable under different storage conditions, preparation methods, and cooking techniques, and that are acceptable to consumers.
- Recommended vitamins and minerals to fortify rice include the micronutrients removed during processing, in addition to micronutrients needed to fill the target population's nutrient gaps. Fortification with multiple micronutrients is recommended, as micronutrient deficiencies often coexist.
- The choice of fortificant used to fortify rice depends on its bioavailability and stability, its impact on consumer acceptability, and the type of technology used.

Rice is the world's second most commonly consumed cereal grain. In recent years, rice fortification technology has evolved. As a result, rice fortification at scale is gaining momentum as a feasible and cost-effective strategy to address micronutrient deficiencies. To date, about 15 countries have introduced rice fortification on either a mandatory or a voluntary basis, embedded in social safety nets, or at limited scale through trials. This article provides an overview of technological challenges for rice fortification and explores rice fortification technologies available to produce fortified rice. It also discusses the use of potential fortificants (vitamins and minerals).

“As for food fortification in general, rice should be fortified with micronutrient forms that are available for absorption by the body, and that remain stable”

Technological challenges for fortifying rice

As for food fortification in general, rice should be fortified with fortificants that are available for absorption by the body, and that remain stable during processing, storage, transport, preparation, and cooking methods and practices including discarding excess water.¹ Rice is consumed as a whole kernel, which complicates the fortification process and requires specialized technology. In contrast to flour fortification, where the premix and flour are both in powder form and can be easily blended, this is not an option with rice.

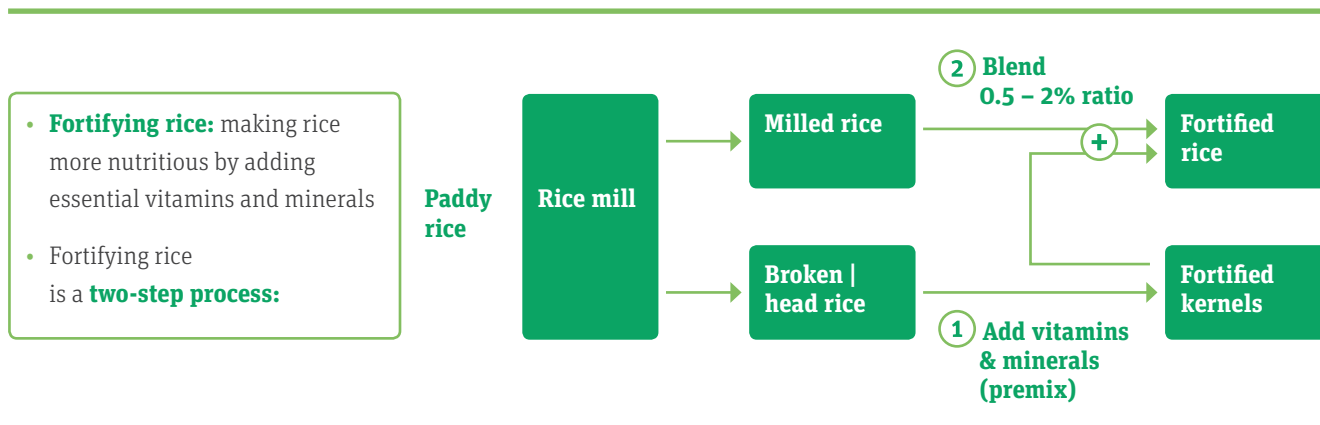
The micronutrients in the fortificant mix should not interact with each other and/or with the rice matrix, as this may influence color, taste and stability, thus lowering consumer acceptability. The fortificants must remain stable during different means of preparation such as washing before cooking, soaking, cooking in different amounts of water, and for varying amounts of time.^{2,3}

Appropriate quality assurance and quality control, as well as monitoring, are needed throughout the rice fortification process to ensure that standards are met and that the fortified rice effectively improves the nutritional health of the consumer. Please refer to the contribution by Kupka et al (pp. 68–72) for more information on monitoring.

Overview of available technologies for rice fortification

Dusting

Dusting is a fortification technology that adds micronutrients onto the surface of the rice grains. Dusting relies on electrostatic force to bind the fortificant in a dry powder form to the surface of the milled rice grains. This technology provides limited nutrient protection when rice is washed, soaked or cooked in excess

FIGURE 1: Two-step process of rice fortification through coating or extrusion technology

water, which is then discarded. In the United States, dusting is acceptable since rice is not washed prior to cooking, nor cooked in excess water. All packaged fortified rice sold in the United States includes a label advising against washing or cooking in excess water.

Coating and extrusion

As illustrated in **Figure 1**, fortified rice is produced using a two-step process. First, coating or extrusion technology is used to produce fortified kernels. Second, the fortified kernels are blended with non-fortified rice at a ratio of 0.5% to 2% to result in fortified rice.

Option 1: Coating technology for production of fortified kernels

Coated fortified kernels are produced by coating rice grains, typically head rice, with a liquid fortificant mix. Additional ingredients, such as waxes and gums, are used to ‘fix’ the micronutrient layer or layers on the rice grain. Whole or head rice is evenly spray coated with micronutrients and other ingredients to preserve the coating. This is usually done in large rotational drum or pan coating machines. The coated kernels are then dried to yield fortified kernels. This technology concentrates the micronutrients on the surface of the rice grains. When cooked, the coating dissolves, spreading the micronutrients throughout the cooked rice. Where rice is washed or soaked, coated fortified kernels must be rinse-resistant so as to ensure micronutrient retention.

Option 2: Extrusion technology for production of fortified kernels

Extruded fortified kernels are formed by combining water and a fortificant mix with rice flour which is usually made from grinding lower value and non-contaminated broken rice, to form a dough (**Figure 2**). The dough is passed through an extruder, producing a fortified kernel visually similar to a non-fortified

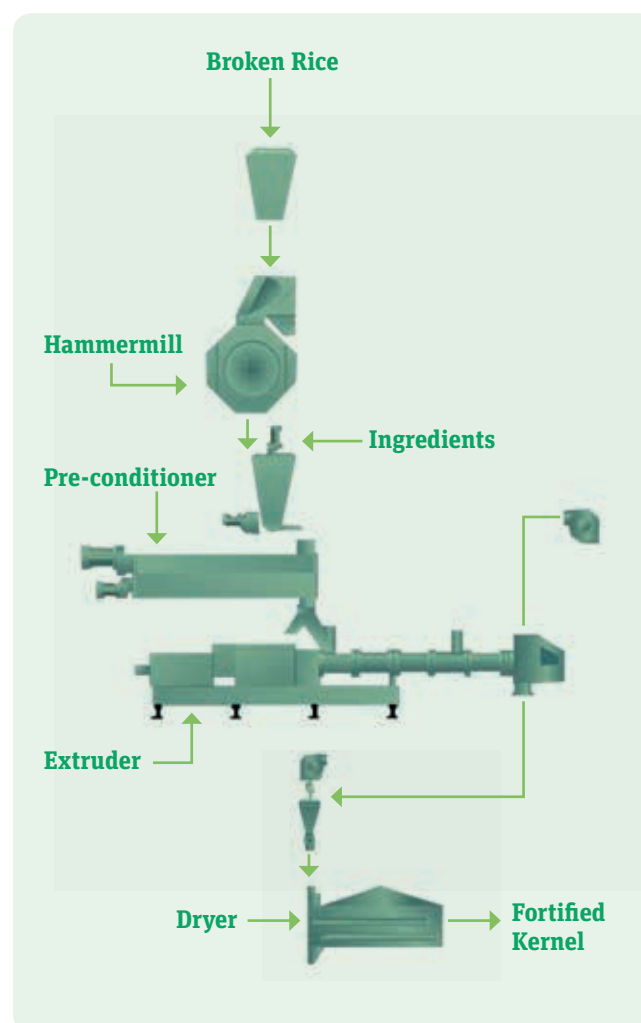
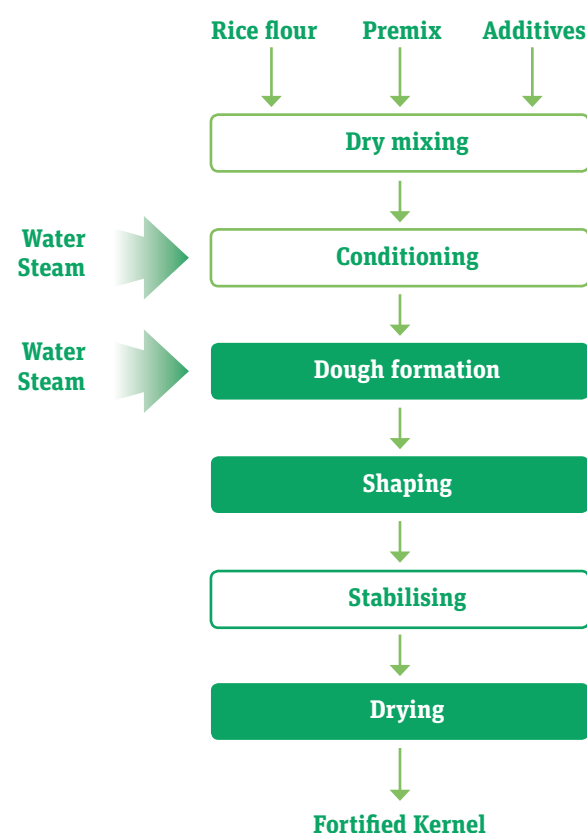
rice grain. Micronutrients are equally distributed inside the fortified kernel, with only a few particles left on the surface. This reduces the exposure to the environment and hence micronutrient degradation. The extruded fortified kernels are dried, reducing the water content to 14% or less, thus increasing stability during storage.

The amount of starch that is gelatinized in the fortified kernel influences color, texture and stability during soaking and cooking. This is affected by the temperature and the amount of water used during extrusion. In **Cold extrusion** (30°C–50°C), a pasta press is used to “shape” the dough and form opaque fortified kernels. This requires binders to be added or a subsequent boiling step to produce a cohesive product. **Warm extrusion** (60°C–80°C) also uses a pasta press, but adds a pre-conditioner with steam, or is equipped with a steam-injection device to produce fortified kernels that appear more translucent and more closely resemble non-fortified rice. An emulsifier can be used, but no additional additives are required. **Hot extrusion** (80°C–110°C) is more energy-intensive and, although not a requirement, ideally uses more sophisticated equipment. It can include a preconditioner, and can rely on a double screw extruder to produce the fortified kernels. An emulsifier (monoglyceride) can be added to maintain stability during storage of the fortified kernels. The resulting fortified kernels closely resemble different types of rice, with different degrees of translucency and texture.²

Fortified kernels made by either warm or hot extrusion are similar to non-fortified rice in their uptake of water during cooking, cooking time, and firmness. Kernels made by cold extrusion have a softer texture. In practice, most fortified kernel production with cold extrusion utilizes additional heat to improve the firmness and appearance, and can therefore be categorized as warm extrusion (see **Figure 3** for the appearance of fortified kernels using extrusion at different temperatures).

Step 2: Blending for fortified kernels and non-fortified rice

The coated or extruded fortified kernels are blended with non-

FIGURE 2: Basic extrusion steps

fortified rice through a continuous or batch mixing process (Figure 4). The blending ratio, typically between 0.5% and 2%, depends on the nutrient content of the fortified kernels and the desired level of fortification. Quality assurance and quality control are needed to ensure uniform blending at the correct ratio.

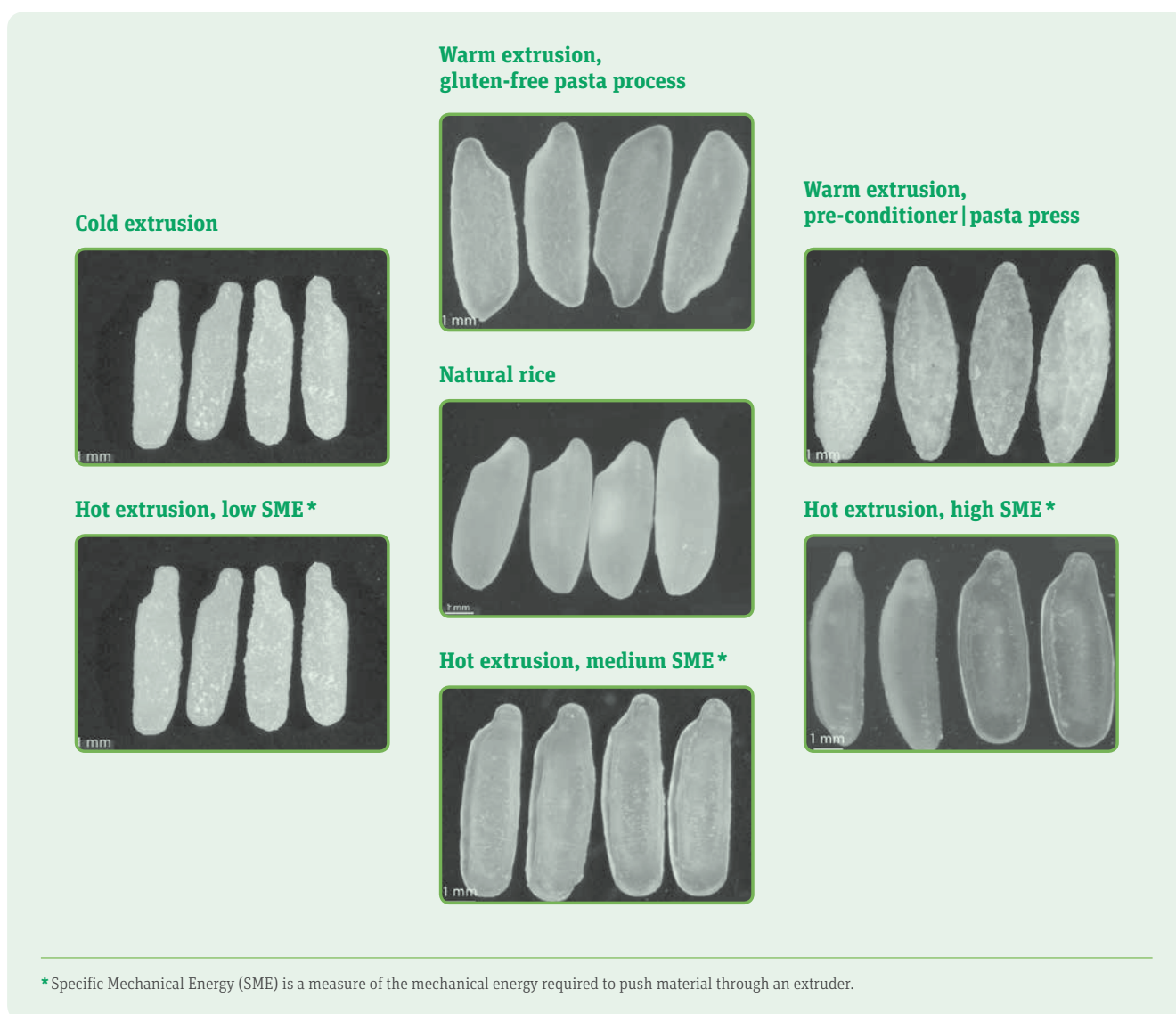
Other approaches to increase micronutrient intake through rice include parboiling, soaking, biofortification and communication for behavior change to increase consumption of brown rice.

Parboiling is not a fortification technology. No micronutrients are added to the rice; rather, parboiling causes the existing nutrients in the outer layers to be transferred and retained in the starchy endosperm of the rice grain. Consequently, parboiling enhances the intrinsic nutrient value of rice. The level of niacin, vitamins B₁ (thiamin) and B₆ (pyridoxine) is around three times as high in parboiled rice as it is in regular milled rice. For niacin and pyridoxine, the level in parboiled rice is similar to brown rice. However, parboiling does not increase the level of minerals, such as iron and zinc, nor is it a source of vitamin A or

vitamin B₁₂. Overall, parboiled rice or brown rice is more nutritious than milled white rice, but only covers a limited part of the suggested micronutrients to add to fortified rice. Parboiled rice can be fortified.

For additional information on biofortification, and on consumption of brown rice, please refer to the contribution by Pachon et al (pp. 26–30). Soaking is not discussed in this supplement, as research into this subject is still in initial stages.

“Micronutrients recommended for rice fortification are those which are removed during processing, in addition to those which address a target population’s nutrient gaps”

FIGURE 3: Visual appearance of natural rice grains and extruded rice kernels produced with cold, warm and hot extrusion

Overview of commonly used fortificants

Micronutrients recommended for rice fortification are those that address a target population's nutrient gap in addition to those removed during processing. Fortification with multiple micronutrients is recommended, as micronutrient deficiencies often coexist in low- and middle-income countries. The selection of fortificants depends not only on their bioavailability, stability, and sensory acceptability, but also on the fortification technology utilized. For additional information on fortificants, please refer to the contribution by de Pee and Fabrizio (pp. 52–56).

To be effective as a fortificant, the micronutrient form must be bioavailable. In other words, the body must be able to effectively absorb and utilize the micronutrient. In addition, the chosen fortificant must not affect the color or taste of the fortified rice. Different forms of micronutrients have varying degrees of bioavail-

ability and degrees to which they affect the appearance and taste of fortified rice.

The most commonly used micronutrients and their fortificants are discussed below.

Iron

Different forms of iron offer trade-offs between bioavailability and properties impacting consumer acceptance. The iron fortificants recommended for wheat and maize flour fortification (e.g. ferrous sulfate, ferrous fumarate or sodium iron EDTA) are nearly unnoticeable to the consumer because the relevant iron fortificant is equally distributed throughout the fortified flour. However, when concentrated in a fortified kernel, color and taste may be affected. **Figure 5** shows rice that has been fortified with various types of iron, sometimes resulting in fortified kernels that may not be acceptable to consumers.

Ferric pyrophosphate (FePP) is recommended for rice fortification as it does not affect the color of fortified kernels and thus does not negatively influence consumer acceptability. However, the bioavailability of FePP is not as high as of ferrous sulfate, and the total iron that can be added to the fortified kernels is relatively low. A micronized form of FePP can increase bioavailability to some extent. Ferric orthophosphate is sometimes used since it is a nearly white powder; however, bioavailability is below that of FePP.^{4,5}

Recent research by the Swiss Federal Institute of Technology (ETH Zurich), confirms that adding a chelating agent can greatly improve the bioavailability of FePP in rice, matching the bioavailability of ferrous sulfate. The study results are expected to be published in 2015.

Zinc

Adding zinc to rice is relatively easy. Zinc oxide is suitable for the technical needs of fortification and has high bioavailability, with virtually no negative impact on taste, color, or stability for the other micronutrients. Zinc sulfate (ZnSO_4) is less suitable, as it may have a negative impact on vitamin A stability.

Selenium

Where selenium deficiencies exist – for example, in Costa Rica – the preferred form for fortification is sodium selenite.

Vitamins

Similar to wheat and maize flour fortification, **the water-soluble vitamins B₁ (thiamin), B₃ (niacin), B₆ (pyridoxine), B₉ (folic acid), and vitamin B₁₂ (cobalamin)** are frequently used to fortify rice without affecting acceptability. However, there are some stability concerns with respect to vitamin B₁ when fortified rice is stored at elevated temperatures. Vitamin B₂ (riboflavin) changes the color of the fortified kernels, which reduces consumer acceptability. It is therefore not typically added to rice even when there is a public health need.

Vitamin A is a fat-soluble vitamin commonly used to fortify vegetable oils, but also wheat and maize flour. The preferred form is retinyl palmitate, in combination with a powerful antioxidant, such as butylated hydroxytoluene (BHT). This ensures stability during storage. Among the vitamins used in rice fortification, vitamin A is the most sensitive to the environment and preparation, including such factors as light, heat, and pH.

FIGURE 4: Production methods for batch and continuous blending to produce fortified rice

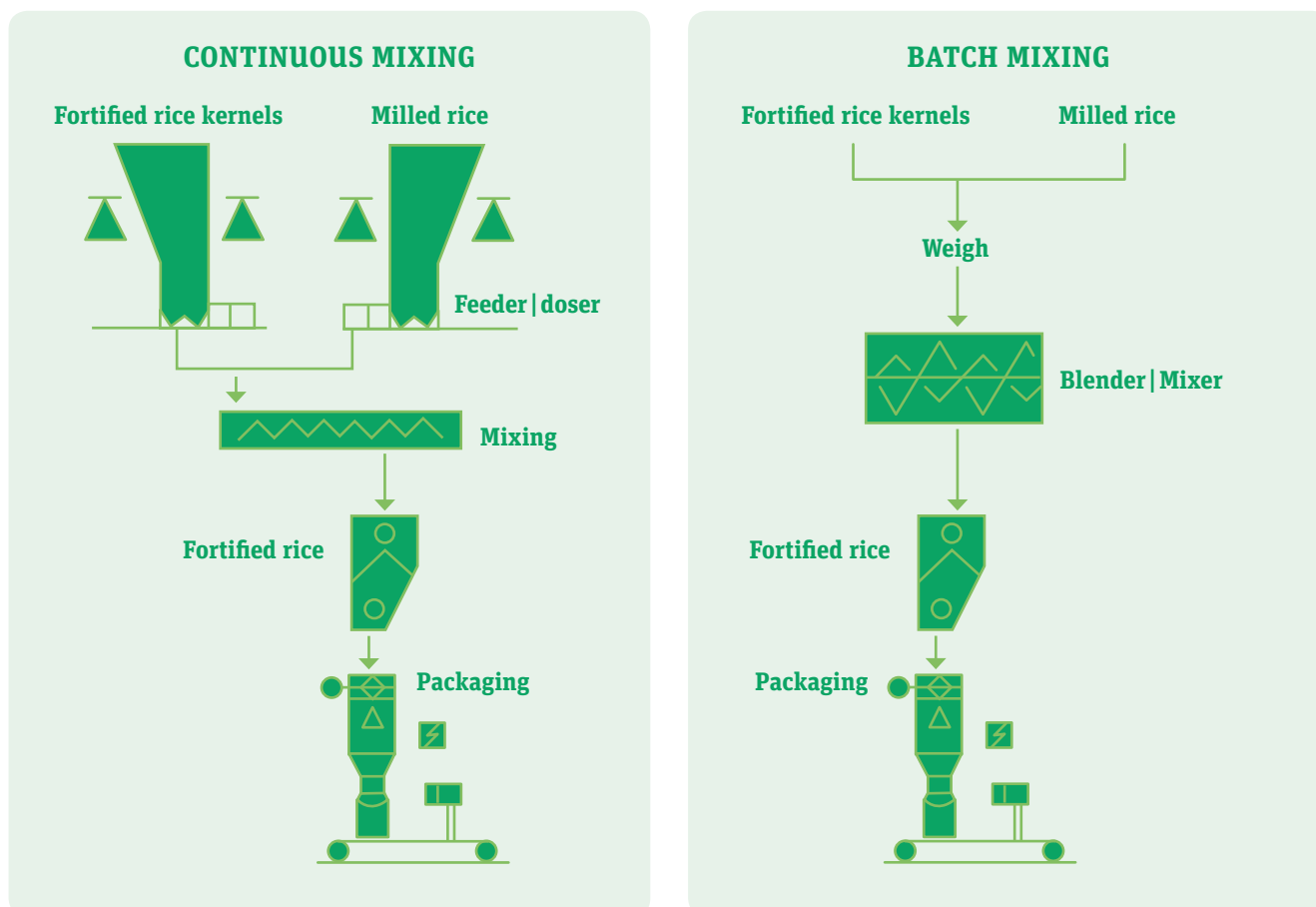


FIGURE 3: Visual appearance of natural rice grains and extruded rice kernels produced with cold, warm and hot extrusion

Some countries also fortify with **vitamin E**, using a spray-dried α -tocopheryl acetate form. **Vitamins D and K** are possible in rice fortification; however, they are not yet used in any of the rice fortification programs.

Other

Overall, rice is a good source of amino acids except for lysine; therefore, fortification with lysine can increase the biological value of rice protein. Although the recommended form is highly water-soluble, the majority of lysine in extruded fortified kernels is retained during washing and cooking.²

“The technology for effective fortification is now available for rice, the world’s second most commonly consumed cereal grain”

Conclusion

The technology for effective fortification is now available for rice, the world’s second most commonly consumed cereal grain. The choice of technology must take into account retention of nutrients during preparation (soaking, washing and cooking), and consumer acceptability (taste, shape, and color). The use of rinse resistant coating or extrusion (hot or warm) to produce fortified kernels meets nutrient retention and consumer acceptability requirements. Both technologies involve a two-step pro-

cess: first, production of the fortified kernel, and second, blending of fortified kernels with non-fortified rice.

The fortificant used is also important as it influences consumer acceptability and the effectiveness of fortified rice.

References

1. Allen LH, de Benoist B, Dary O et al, eds. Guidelines on Food Fortification with Micronutrients. Geneva: World Health Organization and Food and Agriculture Organization of the United Nations, 2006.
2. Steiger G, Muller-Fischer N, Cori H et al. Fortification of rice: technologies and nutrients. *Ann N Y Acad Sci* 2014;1324:29–39. doi: 10.1111/nyas.12418.
3. Alavi S, Bugusu B, Cramer G et al. Rice Fortification in Developing Countries: A Critical Review of the Technical and Economic Feasibility. Washington DC: A2Z Project/Academy for Educational Development, 2008.
4. Aggett PJ. Population reference intakes and micronutrient bioavailability: a European perspective. *Am J Clin Nutr* 2010;91:1433S–1437S. doi:10.3945/ajcn.2010.28674C
5. Hurrell R, Egli I. Iron bioavailability and dietary reference values. *Am J Clin Nutr* 2010; 91(5):1461S–1467S. doi: 10.3945/ajcn.2010.28674F

Costs and Financing for Rice Fortification

**Katrien Ghooos, Cecilia Fabrizio,
Jennifer Rosenzweig**
World Food Programme Regional Bureau for Asia

Key Messages

- The cost of rice fortification is determined by the structure, capacity and scale of the rice industry and fortified rice market, the complexity of the fortified rice supply chain, and the regulatory environment.
- The production of fortified kernels is the most significant cost factor in the production of fortified rice.
- The cost of the fortificant mix as part of the total cost of the fortified rice is nearly negligible.
- Appropriate planning for kernel production should anticipate needs as the program expands, while avoiding market distortions caused by a limited number of fortified kernel sources.
- Optimization of the supply chain and fortified kernel production capacity is essential to enhance the cost-effectiveness of rice fortification.
- When rice fortification is scaled up, production reaches economies of scale, and costs are driven down.
- Calculating a universal cost figure for rice fortification is not possible due to the multitude of contextual variables which influence its cost.
- Experience from a limited number of large-scale rice fortification programs, as well as trial and pilot studies, demonstrates that the percentage retail price increase for fortified rice ranges from 1% to 10%.

Introduction

Globally, two billion people are affected by micronutrient deficiencies. These deficiencies negatively impact socioeconomic development at the individual, household and national level. Reducing undernutrition and micronutrient deficiencies has the potential to boost GDP by up to 11% in Asia and Africa, to reduce by more than half the global burden of disability for children under age five, and to prevent more than one third of global child deaths per year.¹

In 2008, the Copenhagen Consensus, a global think tank of Nobel Prize-winning and prominent economists, found that micronutrient interventions, including fortification and supplementation to improve micronutrient intake, were the most cost-effective intervention to address global development challenges. The 2012 Copenhagen Consensus reaffirmed the 2008 conclusion.

Rice, the staple food for three billion people globally, is a good source of energy, yet a poor source of micronutrients. Therefore making rice more nutritious through large-scale fortification has the potential to be a cost-effective intervention that can significantly improve micronutrient health and support economic growth.

The cost of rice fortification is driven by a multitude of context-specific variables, including the structure and capacity of the rice and larger food industries, the complexity of the fortified rice supply chain, the regulatory and policy environment, and the scale at which fortification is implemented. This paper presents the context-specific factors that must be considered in order to determine the cost for rice fortification.

“The cost of rice fortification is driven by a multitude of context-specific variables”

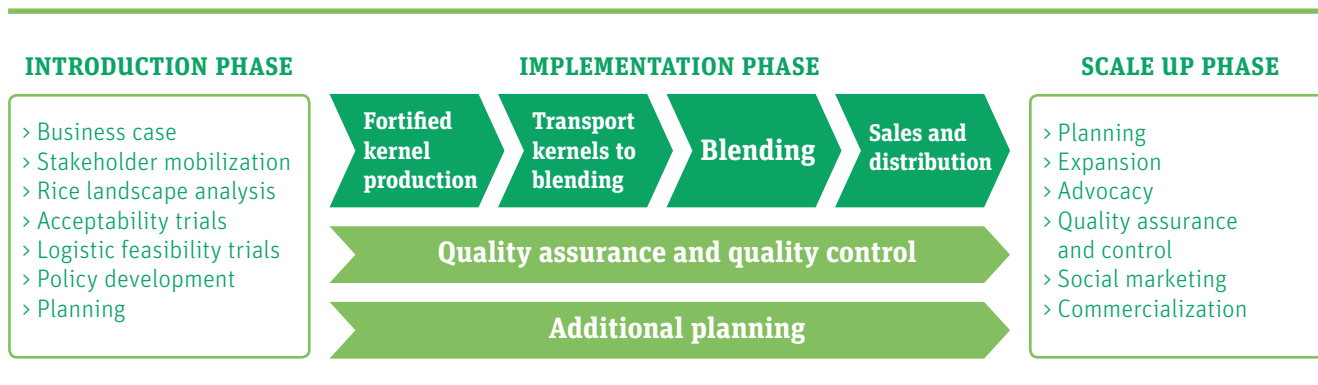
Costs to introduce, implement and scale up rice fortification

Experience with rice fortification has demonstrated that the calculation of a universal cost figure for rice fortification is not possible due to the multitude of contextual variables that influence it. What has been shown in a limited number of large-scale rice fortification programs and various trial or pilot settings is an increase in the retail price of fortified rice of 1% to 10%. As rice fortification expands, economies of scale will be achieved, and costs should fall.²⁻⁸

Figure 1 illustrates how costs vary throughout the three phases of a rice fortification program: introduction, implementation, and scale-up.

Phase 1: Costs during the introduction phase

Costs during the introduction phase are relatively low and are

FIGURE 1: Phases of rice fortification

usually incurred only once. Introduction costs include: stakeholder mobilization, the rice landscape analysis, a health needs assessment, a cost-benefit analysis, context-specific logistical feasibility and acceptability trials, development of a business case, advocacy, and policy and legislation development. Components of policy and legislation development include standard-setting, setting up of a quality control system, and overall project management.

Decisions based on the information gathered and the actions taken will influence the costs incurred during the implementation and scale-up phases. Key decisions with cost implications include: how to source or produce fortified kernels; where and at what scale to blend fortified kernels with non-fortified rice to produce fortified rice; and, which delivery option is most appropriate. For additional information on delivery options, please refer to the contribution by Codling et al (pp. 37–42).

Phase 2: Costs components during the implementation phase

As illustrated in **Figure 2**, during the implementation phase, fortified kernels are produced and transported to blending sites. Fortified kernels are blended with non-fortified rice to produce the fortified rice, which is then sold in the commercial market or distributed through social safety nets. In addition to the specific costs related to the fortified kernel production and blending steps, costs for quality assurance and control, and additional planning for scaling up will be incurred.

Costs of fortified kernel production

The production of fortified kernels is the most significant cost factor in the production of fortified rice. Different fortified kernel production technologies vary as to the capital investment they require, the level of recurring costs, and the quality of the kernel produced. Fortified kernel production costs include equipment, broken or head rice as raw materials, energy, labor, and fortificant mix. These costs vary depending on the context, however.

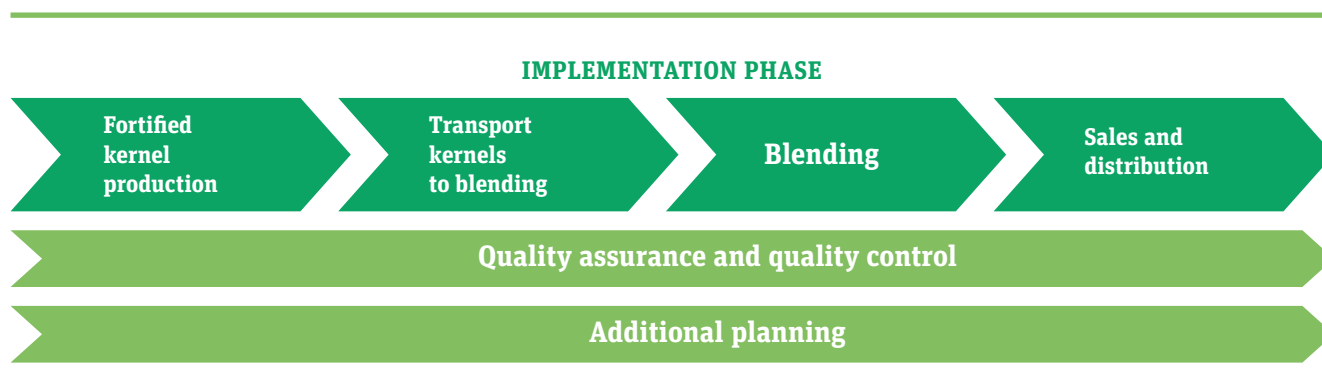
“The production of fortified kernels is the most significant cost factor in the production of fortified rice”

Cost of fortified kernel production equipment: Coating technology requires investment in drums and spray-dryers. Extrusion technology requires rice flour production equipment, extruders, and conveyers or driers. Hot extrusion uses the most sophisticated equipment and therefore requires the highest capital investment. However, hot extrusion can produce a larger quantity and different quality of kernels than either warm or cold extrusion.

Although fortification technologies vary in the capital investment required and the recurring costs incurred, experience so far indicates that the specific technology used does not influence the overall cost of fortified rice. Rather, contextual factors – such as the price of raw materials, labor, energy, and the scale of production – drive the cost.^{2,9}

Therefore the choice of technology should not be based on a simple cost comparison of capital costs. Rather, the decision should be made based on consumer preferences, the anticipated scale of the rice fortification program, the potential location for fortified kernel production and blending, the recommended number, type and level of micronutrients, and the preferred blending ratio. For more information on the factors impacting the choice of technology, please refer to the contribution by Montgomery et al (pp. 57–62).

Cost of broken rice or head rice: Rinse-resistant coating technology applies the fortificant mix to the surface of head rice to produce the fortified kernels. Extrusion technology uses rice flour from broken rice, which is lower in cost compared to head rice. The rice flour is combined with micronutrient fortificant mix to produce fortified kernels. Therefore, as a raw material, the source and price of broken or head rice have a significant impact on the cost of producing fortified kernels.

FIGURE 2: Costs components during the implementation phase

Large mills may have an opportunity to use their own supply of broken or head rice to produce fortified kernels, thus adding value to their existing supply chain. However, if kernel production occurs outside the large mills, there will be costs for purchasing and transporting the broken or head rice to the fortified kernel production sites. For description of different kernel production and blending scenarios please refer to the contribution by Yusufali et al (pp. 43–49).

Cost of fortificant mix: Fortified rice kernels are a mixture of rice and fortificant mix. The fortificant mix is a relatively small cost component of the fortified kernel. As for its contribution to the overall cost of fortified rice, the fortificant mix is a nearly negligible cost.⁴ Given this, and the fact that micronutrient deficiencies tend to coexist in low- and middle-income countries, it is highly recommended to fortify rice with multiple micronutrients so as to achieve a greater public health impact. For additional information on determining micronutrient content, please refer to the contribution by de Pee et al (pp. 20–25).

Energy costs: In addition to head or broken rice, the energy required for manufacturing is a significant cost factor. For both coating and extrusion technology, the final drying process is the most energy-intensive part of the fortified kernel production process.

Other costs for fortified kernel production: Other costs that influence the production of fortified kernels are labor (including special technical skills that may be needed, depending on the technology used), plant configuration (e.g., which extruder is combined with which dryer),⁵ recurring costs (such as maintenance and repairs), and overhead expenses such as administration, interests, and depreciation.

Costs for transport of fortified kernels to blending sites

The costs of transporting the fortified kernels from production sites to the blending sites depends on the source of fortified kernel (domestic production versus imported). The transportation costs for imported kernels will be influenced by import fees, customs clearance, and transport from the port of entry to blending

sites. Transport costs also vary according to the mode of transportation, distance, supply chain complexity, and product volume.

Costs of blending

The cost of blending fortified kernels with non-fortified kernels includes the initial equipment investment and the recurring costs. The capital investments will include the dosing and/or blending system, the fortified kernel feeder and scale, and/or a mixer and scale. The recurring costs include storage of the fortified kernels, quality assurance, other operating costs (labor, electricity, etc.) and repayment of any loans.

“The costs for quality assurance and quality control depend on whether existing systems can be adapted and strengthened”

Costs to sell and distribute fortified rice

The sale and distribution of fortified rice should leverage existing distribution channels, which limits costs for these functions. When fortification is voluntary, additional costs may be incurred for (social) marketing and advertising to generate demand for the fortified brands. When fortification is mandatory or when fortified rice is distributed through social safety nets, costs may be incurred to increase awareness or to dispel potential misconceptions. For a discussion of the factors affecting the choice of delivery options, please refer to the contribution by Codling et al (pp. 37–42).

Quality assurance and quality control (QA/QC)

The costs for quality assurance and quality control depend on whether existing systems can be adapted and strengthened, or if systems need to be created.^{10,4} Costs for QA/QC include: assessment and certification of the fortified rice and the suppliers;

validation of the blending process to ensure the correct fortification ratio and homogeneous mixing; certification and auditing of laboratory facilities; and the establishment of an integrated regulatory framework.¹⁰ For additional information on the importance of QA/QC, please refer to the contribution by Kupka et al (pp. 68–72).

Costs for additional planning for scaling up

Fortified rice requires a longer production lead time than non-fortified rice due to the additional steps required (kernel production and blending). The levels of some micronutrients in the fortified kernels decline over time, so fortified rice has a shorter shelf life than non-fortified rice. Therefore, the milling industry, wholesalers and retailers must adjust their production cycles, planning, and stock management to accommodate these differences, which also add costs.

Phase 3: Costs during scale-up phase

When rice fortification is scaled up, the essential cost components will decline, due to greater efficiency in the supply chain and economies of scale. In addition, the feasibility of domestic kernel production may also increase with the greater demand for fortified rice. Domestic production should reduce the cost of transporting the fortified kernels to the blending sites. Finally, to get to scale, costs will be incurred for setting up the legislative and regulatory systems, coordination with stakeholders, and communication on the benefits of rice fortification.

“When rice fortification is scaled up, the essential cost components will decline, due to greater efficiency in the supply chain and economies of scale”

Additional large-scale rice fortification cost considerations

The most significant cost factor in fortified rice is the production of the fortified kernels. Therefore, to ensure the potential for rice fortification as a large-scale and cost-effective intervention, the production of fortified kernels must be carefully managed. This can be achieved by: **1)** identifying the optimal inclusion rate of fortified kernels, **2)** optimizing fortified kernel production capacity, **3)** careful planning of scaling-up to ensure availability of fortified kernels, and **4)** preventing market distortion.

Optimal inclusion rate: The inclusion rate is the ratio of fortified kernels to non-fortified rice. The lower the inclusion rate, the lower the cost. Inclusion rates typically range from 0.5% to 2%. This means that 1 kg of fortified kernel can be used to produce 50 to 200 kg of fortified rice, or that 5–20 kg of forti-

fied kernels is needed per metric ton of fortified rice. Therefore, given that the cost of fortified rice is an important cost factor, the inclusion rate needs to be set at its most cost-effective level.

Inclusion rates are determined by the target fortification level of the fortified rice. This level can be reached by varying the concentration of micronutrients per fortified kernel, or by varying the ratio of fortified kernels in the fortified rice. The inclusion rate can be reduced if the fortificant concentration in fortified kernels is higher. However, a higher concentration of fortificant may alter the taste, smell or appearance of the fortified kernels, thus making the fortified rice unacceptable to consumers. Therefore, the optimal inclusion rate to provide the target fortification level and achieve public health impact is a tradeoff between costs and consumer acceptability. For more information on determining the fortification level of fortified rice, please refer to the contribution by de Pee and Fabrizio (pp. 52–56).

Optimal utilization of existing fortified kernel production capacity: Optimal utilization of available capacity is essential in keeping the cost of fortified kernels low. Therefore the higher the production capacity, the higher the unit cost for producing a small quantity of fortified kernels. This is because some production costs are fixed to the specific equipment used, regardless of the volume produced using that equipment.⁴

Planning for scale-up: Scaling up access to fortified kernels needs to be planned carefully so as to ensure adequate availability. Domestic production requires investment in new fortified kernel production sites. During the introduction phase, the financial risk of investing in fortified kernel production equipment can be reduced by setting up production on a pilot line or by importing fortified kernels. Private-sector investment in the production of fortified kernels can then be delayed until the implementation phase. For more information on how Bangladesh developed their domestic production, please refer to the contribution by Ebbing et al (pp. 79–82).

Prevention of market distortion: Fortified kernel production should be planned and supported in a way that promotes sufficient competition. Favorable conditions for competitive investment in fortified rice production could include access to cheap loans, tax exemptions and adequate regulatory monitoring. This may require a set of temporary measures until a market equilibrium can be established.

Financing

The financing of rice fortification must be shared between the public sector, the private sector, and donors. The magnitude of the costs, and their distribution across stakeholders, is dependent upon its phase (introduction, implementation, and scale up) and delivery option (mandatory, voluntary and social safety net).^{3,4}

Public sector: The public sector typically allocates funding for the introduction of rice fortification, especially in the context

of mandatory fortification, or when rice is distributed through social safety nets. This is likely to include costs for health needs assessment, and may include conducting a landscape analysis, stakeholder mobilization, development of a business case, advocacy and policy development. During implementation and scale-up, government funds are necessary to support regulatory monitoring for all types of delivery.

Donors often provide financial support to complement public sector financing, particularly during the introduction phase. When fortified rice is distributed through social safety nets, donors may continue to provide financial and technical support during the implementation phase, while the public sector gradually becomes the sole financier after scale-up.

Private sector: For all delivery options, the private sector typically bears the burden of production and often technology development costs. The private sector will make its lowest contribution for social safety net distribution and its highest contribution for voluntary fortification. For mandatory and voluntary delivery options, the private sector will also take on all costs related to production of the fortified rice, including internal quality assurance and control. In addition, for voluntary delivery, the private sector will also bear the costs of marketing and promotion.

Consumer: Most of the costs incurred by the private sector, in both mandatory and voluntary delivery options, will be passed on to the consumer through an increased retail price. Government can control the fortified rice price in a way that compensates the private-sector producers while minimizing the increase for the consumer. For an example of price setting that addresses stakeholder concerns, please refer to the contribution by Tacsan et al on Costa Rica (pp. 73–78).

Conclusion

The cost of introducing, implementing and scaling up rice fortification is determined by a multitude of context-specific factors. The most significant factors are the cost of raw materials, energy, labor, and scale of production rather than the choice of technology and the fortificant mix. Experience from a limited number of large-scale rice fortification programs, as well as trial and pilot studies, demonstrates that the percentage retail price increase for fortified rice ranges from 1% to 10%. However, more analysis is needed to fully understand the different cost components, their relative contribution to the overall cost, and their impact on retail prices.

Planning for fortified kernel production is essential and should anticipate needs in the short, medium and long term as the fortified kernel cost is the largest cost component for fortified rice. Therefore, development of a business case for fortified kernel production is required in the introduction phase of the rice fortification program, based on results of the landscape analysis.

Effective programs are based on strong public-private partnerships that share the costs, within an equitable regulatory framework.

“Effective programs are based on strong cost-sharing public-private partnerships”

References

1. Haddad L. Ending Undernutrition: Our Legacy to the Post 2015 Generation. Sussex, UK: Institute of Development Studies in partnership with the Children's Investment Fund Foundation, 2013.
2. Alavi S, Bugusu B, Cramer G et al. Rice Fortification in Developing Countries: A Critical Review of the Technical and Economic Feasibility. Washington DC: A2Z Project/Academy for Educational Development, 2008.
3. Forsman C, Milani P, Schondebare J et al. Rice fortification: a comparative analysis in mandated settings. *Ann N Y Acad Sci* 2014;1324:67–81.
4. Roks E. Review of the cost components of introducing industrially fortified rice. *Ann N Y Acad Sci* 2014;1324:82–91.
5. Steiger G, Müller-Fischer N, Cori H et al. Fortification of rice: technologies and nutrients. *Ann N Y Acad Sci* 2014;1324:29–39.
6. Knowles J. In-country assessment of the feasibility of rice fortification as part of an integrated package to prevent iron deficiency and anemia. UNICEF EAPRO, November 2008.
7. Unpublished data from WFP-supported trials in Bangladesh and Cambodia.
8. Bagriansky J, Sayo A. Economic Analysis of Philippines National Fortification Program: Applying Global Evidence to the National Environment. August 2011.
9. Personal communication with representatives from DSM, PATH and Wright present at the “Scaling up Rice Fortification in Asia” workshop, held in Bangkok, September 2014.
10. Allen L, de Benoist B, Dary O et al, eds. Guidelines on food fortification with micronutrients. Geneva: World Health Organization/Food and Agriculture Organization, 2006.

Lessons Learned from Flour and Salt Fortification

Roland Kupka

Nutrition Section, UNICEF Headquarters, New York

Cecilia Fabrizio, Jennifer Rosenzweig

World Food Programme Regional Bureau for Asia

Key Messages

- Globally, wheat flour fortification and salt iodization have achieved remarkable public health benefits.
- Government-led coordination mechanisms and national public-private partnerships underpin successful programs.
- Mandatory legislation and evidence-based fortification standards are necessary to achieve a public health benefit; however, the legislation needs to be accompanied by adequate regulatory monitoring.
- Industry consolidation is a key driver of success.
- Targeted communication is important, but cannot replace regulatory monitoring in the context of mandatory legislation.

Introduction

Flour and salt have been successfully used as fortification vehicles to effectively improve micronutrient health throughout the world.¹ Wheat flour and salt were identified early as appropriate food fortification vehicles due to their broad distribution and consumption. The criteria for identifying appropriate foods for fortification include: consumption by a large part of the population; consumption on a regular basis in predictable amounts; central processing; and availability of an easy and cost-effective method for fortification. This article examines the application to rice fortification of lessons learned from flour and salt fortification programs.

Evidence for the success of wheat fortification

Mandatory wheat and maize flour fortification programs have significantly contributed to the reduction of micronutrient deficiencies. Due to wheat's status as the most widely consumed cereal product, and its micronutrient stability and cooking ver-

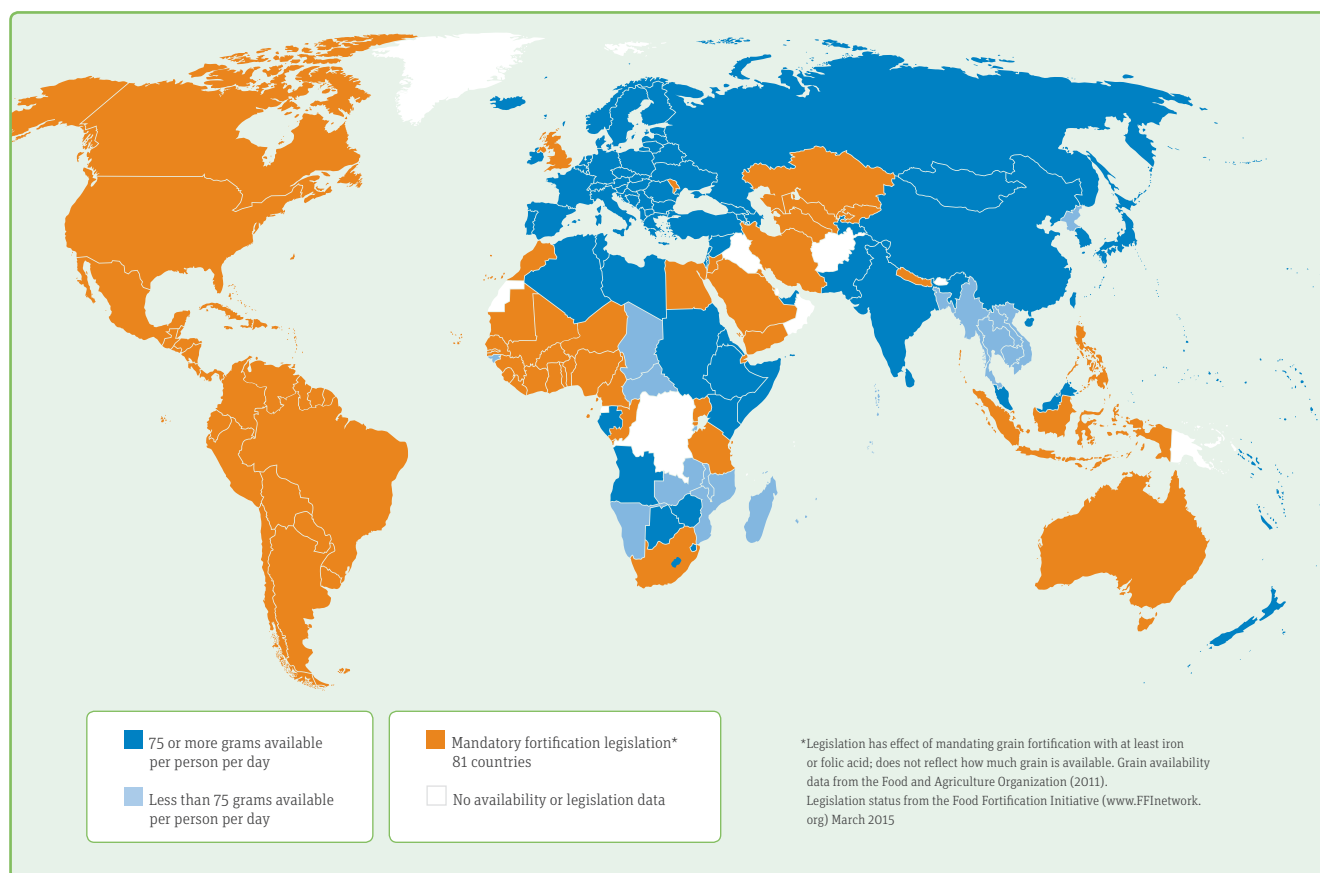
satility, wheat flour is an ideal candidate for micronutrient fortification.² Wheat flour has a long history of fortification, with programs in the United States and United Kingdom since the early 1940s. Today, 81 countries mandate fortification of industrially milled wheat flour with at least iron or folic acid, and another six countries use voluntary methods to fortify at least half of their industrially milled wheat flour (**Figure 1**).³ It is estimated that these efforts are responsible for iron or folic acid fortification of 31% of the world's industrially milled wheat flour.

“Flour and salt have been successfully used as fortification vehicles to effectively improve micronutrient health throughout the world”

Wheat fortified with folic acid has significantly reduced the incidence of neural tube defects (NTDs), which are birth defects of the brain, spine, or spinal cord. These defects occur due to the inability of the spinal cord to close within the first few weeks of pregnancy, which is often before a woman is aware she is pregnant. Fortification of staple foods is therefore the most effective means to ensure adequate levels of folic acid during this critical period.⁴ As shown in **Figure 2**, studies across multiple countries have attributed folic acid fortification to a significant decline in NTDs. NTD declines vary by country based on the magnitude of the problem, and due to the different amounts of folic acid added to flour and the NTD incidence prior to fortification.⁵

Evidence for the success of salt fortification

Mandatory salt fortification has significantly contributed to the reduction of iodine deficiency. As recently as 1993, populations in an estimated 110 countries were iodine-deficient. In 2014, after widespread adoption of salt fortification, only 31 countries continued to report moderate or mild iodine-deficient populations (**Figure 3**). The East Asia and Pacific region, with 86% of its households consuming iodized salt, is within reach of the World Health Organization's 90% target level for adequately iodized salt,⁶ and well above the 75% current global level.⁷

FIGURE 1: Wheat availability and fortification legislation³

Key success factors in programs to fortify wheat and salt

Lessons learned and key success factors for wheat and salt flour fortification can be used to inform the introduction and scale-up of rice fortification:

“Success factors for wheat and salt flour fortification can be used to inform rice fortification”

Mandatory fortification achieves greater impact on micronutrient deficiencies than voluntary fortification

Voluntary fortification is a market-based approach that allows individual food manufacturers to determine whether to fortify food products or not. In contrast, mandatory fortification obligates food producers, both domestic and imported, to fortify specific staple foods or condiments with predetermined micronutrients. Governments tend to institute mandatory fortification when a suitable vehicle is available, and when deficiencies are high and affect a large portion of the general population. Compared to voluntary fortification, mandatory fortification

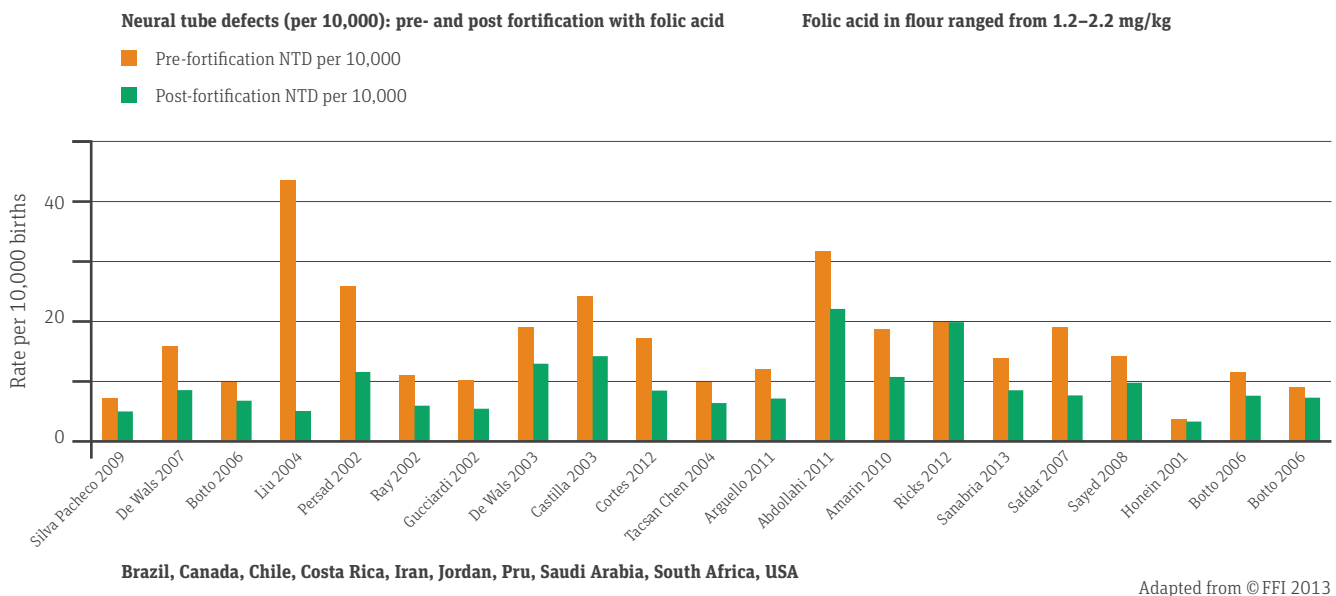
of wheat and salt has been more successful at establishing a sustained source and consumption of fortified foods. Mandatory legislation creates a level playing field that facilitates industry compliance. For these reasons, mandatory legislation has resulted in a larger public health impact than voluntary fortification.

Mandatory legislation needs to be accompanied by evidence-based standards and adequate regulatory monitoring

Governments are responsible for ensuring that food fortification will be both efficacious and effective in reducing micronutrient deficiency in vulnerable populations, while also being safe for the entire population. This is achieved through the enforcement of evidenced-based standards and regulations.

Flour fortification programs have greatly benefited from WHO recommendations on which nutrient compounds are suitable and in what concentrations. In 2009, the WHO and partners provided guidance on national fortification of wheat flour with a range of nutrients, varying by level of extraction, nutrient compound, and estimated per capita flour consumption. Similar recommendations for fortified rice are currently under development by the WHO.

FIGURE 2: Country-level studies showing the reduction of neural tube defects (NTDs) following the fortification of wheat with folic acid⁹



Experiences from wheat flour and salt iodization programs have demonstrated that effective and systematic regulatory monitoring, including monitoring, evaluation and enforcement systems, is a key factor for success.

Regulatory monitoring ensures that fortified foods meet the required nutrient, quality and safety standards. Regulatory monitoring also levels the playing field such that all producers incur the same manufacturing costs. In addition to regulatory monitoring, internal monitoring is necessary, and should be performed by producers themselves to ensure a consistent production of quality product.

If the Total Quality Approach is used for fortification by manufacturers, it structures the process within ISO standards, Good Manufacturing Practices (GMP), Hazard Analysis and Critical Control Points (HACCP) guidelines and traceability systems. It thereby applies a risk-based preventive approach to deviations of quality or safety throughout the process. This approach, in turn, provides stakeholders with the tools for the needed cultural shift towards continuous improvement for a safe product and process at all times. Moreover, it decreases the analytical burden from the manufacturers and regulators.

Periodically, producers should be inspected and monitored by food control authorities (external monitoring) to verify that GMP and internal monitoring systems are being implemented and executed. The allocation of sufficient resources is essential to ensure that such monitoring occurs.

Once programs are performing well (as assessed by quality internal and external monitoring data), stakeholders may choose to conduct assessments at household and/or individual

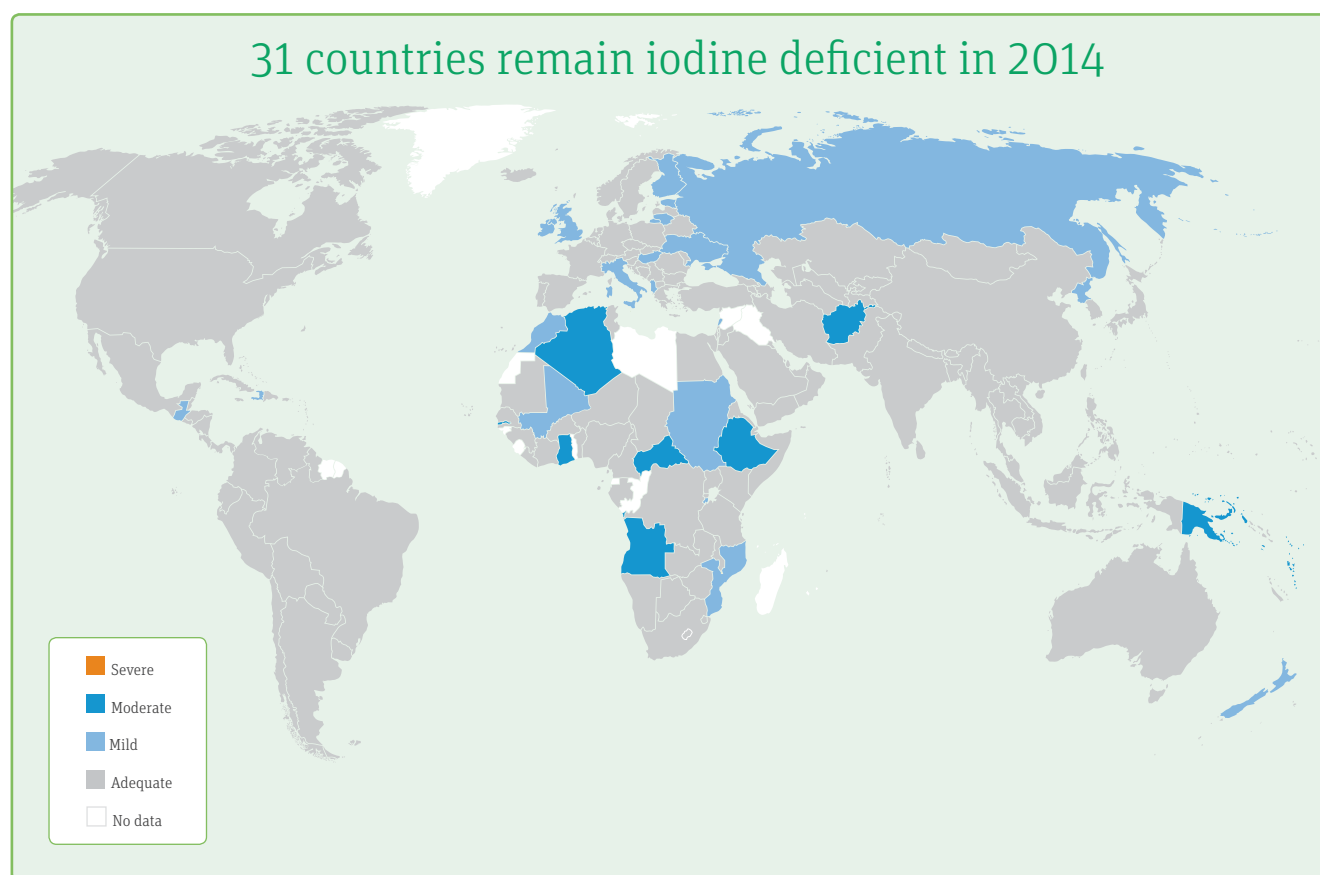
levels to determine coverage and the potential public health impact. Such information may be crucial to be able to justify the use of resources for such programs (see **Figure 4**).

Industry consolidation optimizes the supply chain, reduces fortification cost and enables enforcement

Experience from salt iodization and flour fortification has shown that industry consolidation helps to meet quality and safety standards, and to enforce regulations. In addition, the supply chain becomes streamlined and fortification costs are minimized.

“Industry consolidation helps to meet quality and safety standards, and to enforce regulations”

The relative success of salt fortification in Ghana, India and China demonstrates the benefits of a consolidated industry. In Ghana, where the salt industry has remained fragmented, the country has not seen a sustained shift in household coverage in the past 20 years. In the parts of India where the industry is consolidating, the supply of adequately iodized salt has correspondingly improved. China has a highly consolidated and controlled salt industry and a correspondingly reliable supply, with high household coverage of adequately iodized salt. For additional information on consolidated markets, please refer to Yusufali et al and the accompanying infographics (pp. 43–51).

FIGURE 3: National iodine status in 2014¹⁰

Government leadership and national public-private partnerships underpin successful programs

Food fortification is a public health intervention that is implemented through the private sector.⁸ These public-private partnerships have been, and continue to be, essential to the global success of wheat and salt fortification. Effective partnerships leverage the strengths of both sectors. The private sector supplies production, delivery, and efficiency expertise, while the government sector provides stability and a conducive environment through institutionalization of the program, technical support, and a suitable regulatory environment. In some settings, public-private partnerships have been formalized through national food fortification alliances or equivalent structures. These groups often include food standard authorities, industry, development partners, relevant ministries, consumer groups, and in some cases, academia.

“In mandatory fortification programs, it is advantageous to increase consumer awareness of why fortification is beneficial”

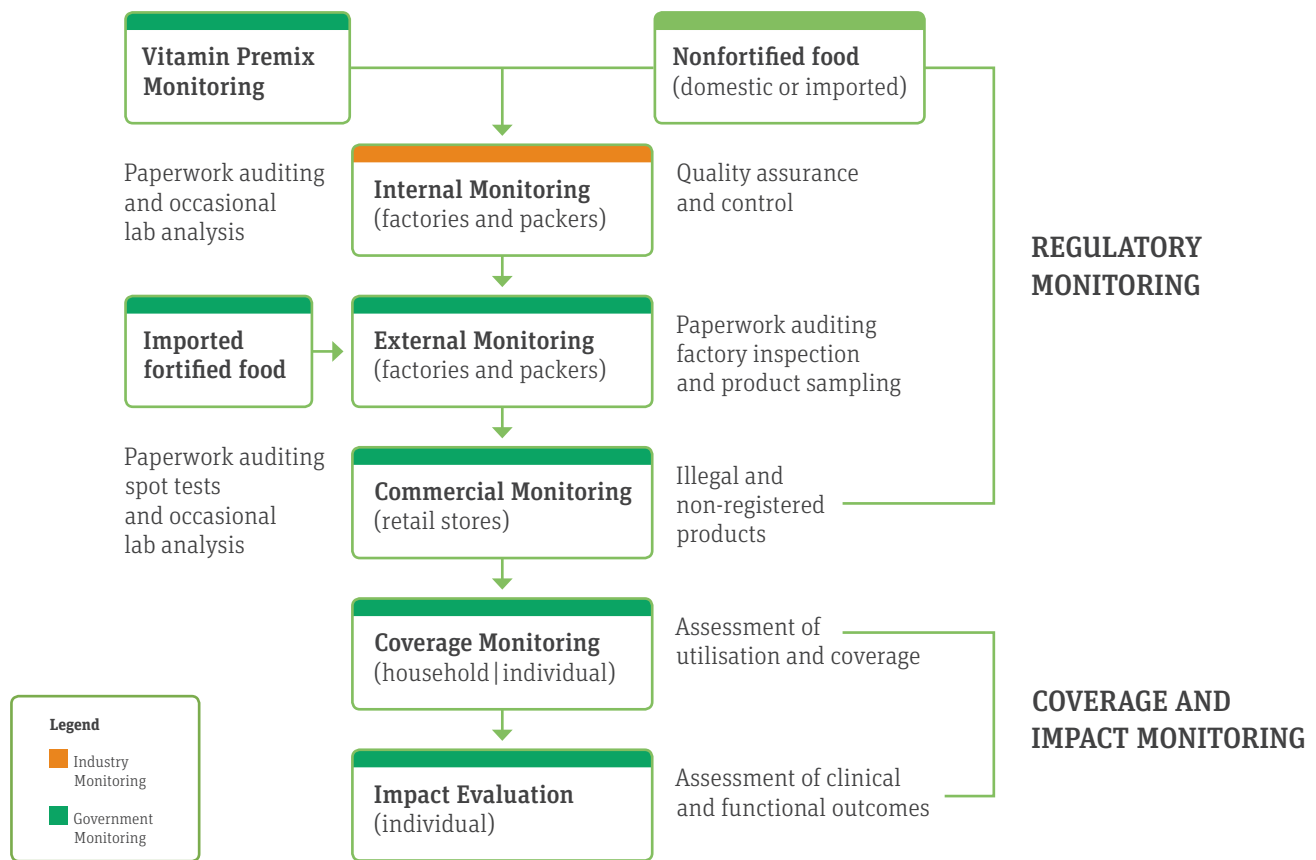
Strong government leadership is necessary for effective public-private partnerships. Leadership is also necessary for the creation of political will and commitment for the development, enforcement, and monitoring of legislation and regulations.

The role of communication in mandatory food fortification programs

Whereas in voluntary food fortification programs it is essential to create demand for the fortified food, in mandatory fortification programs, communication efforts should focus on creating the political commitment to establish necessary legislation, develop evidence-based standards, and ensure compliance through regulatory monitoring. In mandatory fortification programs, it is advantageous to increase consumer awareness of why fortification is beneficial. However, it is not necessary to educate consumers to purchase fortified products over non-fortified products because properly implemented mandatory fortification ensures that the entire food product is fortified.

Conclusion

Globally, wheat flour and salt iodization have achieved remarkable public health benefits. Key lessons learned include the importance of mandatory legislation, supported by evidence-

FIGURE 4: Program success factor: Regulatory monitoring (design)

Adapted from © WHO | FAO 2007

based standards, and adequate regulatory monitoring. Industry consolidation helps to meet quality and safety standards, and to enforce regulations. Advocacy and communication to policy-makers and national stakeholders develops government leadership and commitment and the establishment of effective public-private partnerships for fortification. Rice fortification efforts will benefit from leveraging these key success factors.

References

1. Allen LH, De Benoist B, Dary O et al. Guidelines on food fortification with micronutrients. Geneva: World Health Organization and Food and Agricultural Organization of the United Nations, 2006.
2. Food Fortification Network. Fortification basics: wheat flour. Accessed from www.ffinetwork.org/documents/FortificationBasics.pdf on 20 March 2015.
3. Food Fortification Initiative. Global Progress. Accessed from www.ffinetwork.org/global_progress/ on 20 March 2015.
4. Food Fortification Network. Why fortify? Improved health. Accessed from: www.ffinetwork.org/why_fortify/health.html on 20 March 2015. Countries include Brazil, Canada, Chile, Costa Rica, Iran, Jordan, Peru, Saudi Arabia, South Africa, and the USA.
5. *Sight and Life*. Views, Positions and Statements: Birth defects are reduced and healthcare expenses are averted. Accessed from: www.sightandlife.org/fileadmin/data/Magazine/2011/25_3_2011/views_15_years_of_fortifying_with_folic_acid.pdf on 20 March 2015.
6. World Health Organization. Recommended iodine levels in salt and guidelines for monitoring their adequacy and effectiveness. Geneva, 1996. Accessed from: www.who.int/nutrition/publications/micronutrients/iodine_deficiency/WHO_NUT_96.13/en/ on 20 March 2015.
7. UNICEF State of the World's Children 2015: Reimagine the future, Innovation for every Child http://data.unicef.org/corecode/uploads/document6/uploaded_pdfs/corecode/SOWC_2015_Summary_and_Tables_210.pdf accessed 29 March 2015.
8. Rowe LA, Dodson DM. A knowledge-to-action approach to food fortification: Guiding principles for the design of fortification programs as a means of effectively addressing micronutrient malnutrition. *Health* 2012;4:904–909.
9. Pachon H. Presentation: Review of the public-health evidence of flour fortification impacting serum folate, neural tube defects, serum ferritin, and hemoglobin. Flour Fortification Initiative, 2013, Accessed from www.ffinetwork.org/about/calendar/2013/documents/HealthImpact.pdf on 20 March 2015.
10. Iodine Global Network. National iodine status in 2014. Accessed from www.ign.org/index.cfm on 20 March 2015

Rice Fortification in Costa Rica

Case study

Luis Tacsan

Ministry of Health Costa Rica

Cecilia Fabrizio, Judith Smit

World Food Programme Regional Bureau for Asia

Key Messages

- Costa Rica's long history of food fortification provided the knowledge base and legislative experience for implementing a successful mandatory rice fortification program.
- Engaging food manufacturers and rice millers, and leveraging existing distribution channels, created a sustainable fortification program.
- The public and private sector share costs to develop and support ongoing quality management and monitoring.
- The technology and fortificants used produces fortified rice kernels that are acceptable in taste and appearance to consumers.

Introduction

With a population of approximately four million people, Costa Rica has a long history of government policies to improve the country's public health. Public health initiatives include large-scale food fortification, strengthening the primary health care system, sanitation improvements, and deworming campaigns.

All rice consumed in Costa Rica is fortified with folic acid, vitamins B₁ (thiamin), B₃ (niacin), B₁₂ (cobalamin), E, selenium and zinc. As a staple food, 60% of the rice is domestically produced. The fortification of rice, along with that of other staple foods and condiments, helps to increase micronutrient intake. Per capita rice consumption averages 150 g per day, providing approximately 30% of caloric intake. Rice is relatively affordable, and is about 9% of the cost of the basic food basket.

Costa Rica's success in large-scale rice fortification is primarily due to its food fortification experience, its centralized rice industry, government leadership, and private sector support. This article describes Costa Rica's fortified rice program and analyzes the key factors in its success.

“Costa Rica's success in large-scale rice fortification is primarily due to its food fortification experience, its centralized rice industry, government leadership, and private sector support”

Staple food fortification in Costa Rica

Micronutrient fortification of staple foods and condiments in Costa Rica began in 1974 with the iodization of salt in response to continued micronutrient deficiencies. Despite the implementation of a basic sanitation and deworming program, primary health care strategy, supplementation, health promotion, and complementary feeding activities to improve micronutrient health, the 1996 national nutrition survey found that micronutrient deficiencies remained at critical levels.¹ In addition, a study based on data from the nation's Congenital Disease Registry showed that 12 in 10,000 infants had neural tube defects.²

In response, the government established a cross-sectoral National Micronutrient Commission and expanded its fortification efforts, in partnership with the private sector. Mandatory fortification of wheat flour began in 1997, followed by corn flour in 1999, milk and rice in 2001, and sugar in 2003. See **Table 1** for an overview of the fortified foods in Costa Rica and the fortification level.

Legislative framework for rice fortification

In 2001, the Presidency of the Republic and the Ministry of Health enacted the “Regulations for the Enrichment of Rice.”

TABLE 1: Overview of fortified foods, fortificants and fortification levels in Costa Rica

Food	Average daily consumption	Fortificants	Fortification level
Rice	130 g	Folic acid (vitamin B ₉)	1.8 mg/kg
		Thiamin (vitamin B ₁)	6.0 mg/kg
		Cobalamin (vitamin B ₁₂)	10.0 µg /kg
		Niacin (vitamin B ₃)	50.0 mg/kg
		Vitamin E	15.0 IU/kg
		Selenium	105.0 µg/kg
		Zinc	19.0 mg/kg
Sugar	71.4 g	Vitamin A	8 mg/kg (26,664 IU/kg)
Wheat flour	74 g	Thiamin (vitamin B ₁)	6.2 mg/kg
		Riboflavin (vitamin B ₂)	47.2 mg/kg
		Niacin (vitamin B ₃)	55 mg/kg
		Folic acid (vitamin B ₉)	1.8 mg/kg
		Iron (Ferrous fumarate)	55 mg/kg
Milk	107 mL	Iron (Ferrous bisglycinate)	1.4 mg/250 mL
		Vitamin A	180 µg/250 mL
		Folic acid (vitamin B ₉)	40 µg/250 mL
Maize flour	18.0 g	Iron (Ferrous bisglycinate)	22 mg/kg
		Niacin (vitamin B ₃)	45 mg/kg
		Thiamin (vitamin B ₁)	4 mg/kg
		Riboflavin (vitamin B ₂)	2.5 mg/kg
		Folic acid (vitamin B ₉)	1.3 mg/kg
Salt	9.8 g	Iodine	30–60 mg/kg
		Fluoride	175–225 mg/kg

The legal framework for rice fortification was placed under the umbrella of the 1974 General Health Law. The legislation mandated that all direct for human consumption rice must be fortified, whether the rice is domestically produced or imported. The regulations defined the specific micronutrients and the required fortificant levels. In addition, the regulations assigned external monitoring and quality control to the government and internal monitoring to the rice industry.

Fortified rice supply chain

Costa Rica's rice supply chain is relatively consolidated compared to most rice-growing countries in Asia. Two fortified kernel producers supply the 11 rice milling companies operating in Costa Rica. The millers blend the fortified kernels with non-fortified rice at the specified ratio (0.5%) and sell the fortified rice through their distribution channels. The 11 millers are brought together under the National Association of Rice Industrial Sector (ANINSA). The rice corporation (CONARROZ) is the sole entity allowed to import rice within a set quota.

Setting standards

Setting rice fortification standards started with consideration

of the typical local diet, including consumption of other fortified foods. Other criteria used in selecting the micronutrients and levels of the rice fortificant premix included: the nutrient deficiencies in the population; the interaction between nutrients; the recommended nutritional intake; and the level of rice consumption. The combined micronutrient intake from fortified rice and other fortified foods was determined to be effective and safe. Based on these considerations, the standard was set to require fortification with vitamin B₁ (thiamin), B₃ (niacin), B₉ (folic acid), vitamin B₁₂ (cobalamin), vitamin E, selenium, and zinc.

In Costa Rica rice is not fortified with iron and vitamin B₂ (riboflavin) for two reasons. First, tests showed that the type and concentration of iron recommended at the time (2001) produced changes in both taste and appearance that were unacceptable to consumers. Unless color change is not a problem for consumer acceptability, rice is typically not fortified with vitamin B₂ because it changes the color of fortified kernels. Second, iron and vitamin B₂ were available in other fortified commodities. Note that new formulations of iron are now available that do not impact consumer acceptability of fortified rice. For more information on setting standards for rice fortification, see the contribution by de Pee and Fabrizio (pp. 52–56).

Technology

In Costa Rica, where rice is washed prior to cooking, the initial preference to fortify using dusting technology was deemed inappropriate. Dusting technology, in which polished, milled rice kernels are dusted with a fortificant mix, does not allow for washing or cooking in excess water, as this will wash out the micronutrients. Rather, coating and extrusion technologies were determined to be more suitable for the production of the fortified kernels, as nutrients are retained when rice is washed or cooked in excess water.

Currently, one of the fortified kernel producers uses coating technology and the other producer uses warm-extrusion technology. Refer to the contribution by Montgomery et al for additional information on identification of appropriate rice fortification technology (pp. 57–62).

Quality control

Quality control and monitoring responsibilities are shared by the private and public sectors. The two fortified kernel producers are responsible for guaranteeing the micronutrient concentrations in the fortified kernels.³ Millers are responsible for the accuracy of the blending ratios and homogeneity. For internal monitoring of the blending ratios, sampling is conducted every hour. Some sampling, along with all lab analysis, is done by third-party laboratories to determine compliance against the mandatory rice fortification executive decree. External quality control and evaluation are the responsibility of the Ministry of Health, and are performed by the government's quality control agency. These quality control samples are obtained from retailers at point of sale, as opposed to upstream sampling at manufacturing sites. Government regulations mandate labeling of all rice sold with the assigned quantities of the micronutrients' minimum amounts (per kg). The shared quality control and monitoring process enhances quality control across the supply chain.

Costs

Costs for rice fortification include initial start-up costs and ongoing costs of fortification. Initial costs included the cost of the coating and extrusion technology and the blending machinery, as well as installation and calibration. Ongoing, the primary cost components are: the micronutrient premix costs; production costs of the fortified kernels; and quality control and monitoring costs. Minor costs include blending, storage and transport. In the early days of the program, costs due to fortification rose to about 5–6% of the retail price. As fortified kernel producers and rice millers gained experience and increased production efficiencies, the additional costs fell to less than 1%. This cost-reducing gain in production efficiency is typically observed in food fortification programs. Currently, the estimated additional

cost per kg of rice due to fortification is about US\$ 0.01, or about 0.9% of the retail price.

Impact of micronutrient fortification programs

Although improvements cannot be attributed to any specific fortified food, national impact evaluation and monitoring programs have reported significant improvements in micronutrient status following the introduction of the food fortification program. Given the relatively large per capita intake of fortified rice as part of the overall food basket, rice fortification must have significantly contributed to these improvements in micronutrient status. Reductions in micronutrient deficiencies have been shown both within the general population and among specific groups.

“Significant improvements in micronutrient status have been reported following the introduction of the food fortification program”

Anemia

Costa Rica's anemia prevalence rates have fallen significantly following the introduction of the national fortification program.⁴ In addition to iron deficiency, anemia can also result from deficiencies in vitamin B₁₂ and folate. The 2008–2009 National Survey data,⁵ compared to the 1996 data,¹ showed a 71.2% reduction in the prevalence of anemia among children one to six years of age. Rural areas showed larger reductions in the prevalence of anemia (89.6%) than urban areas (74.6%). National anemia prevalence ranges from 1 to 9.9% and is no longer of public health concern (see **Figures 1 and 2**).

Among women of childbearing age, the National Nutrition Surveys in 1982, 1996¹ and 2008–09⁵ showed a similar significant reduction in anemia prevalence of 46.8% at the national level. Looking at geographic areas, anemia declined 54% in rural areas, 46.3% in urban areas, and 36.4% in metropolitan areas (see **Figures 3 and 4**).

Neural tube defects

The combined food fortification programs have also reduced the prevalence of neural tube defects (NTDs) linked to folate deficiency. Prevalence of NTDs in newborns fell from 11 per 10,000 births in 1982–1996¹ to five per 10,000 births in 2008–2009⁵ (see **Figure 5**).

Key success factors

The success of rice fortification in Costa Rica is due to the following factors:

FIGURE 1: Prevalence of anemia in Costa Rican preschool children; 1982 and 1996 compared to 2008–2009.

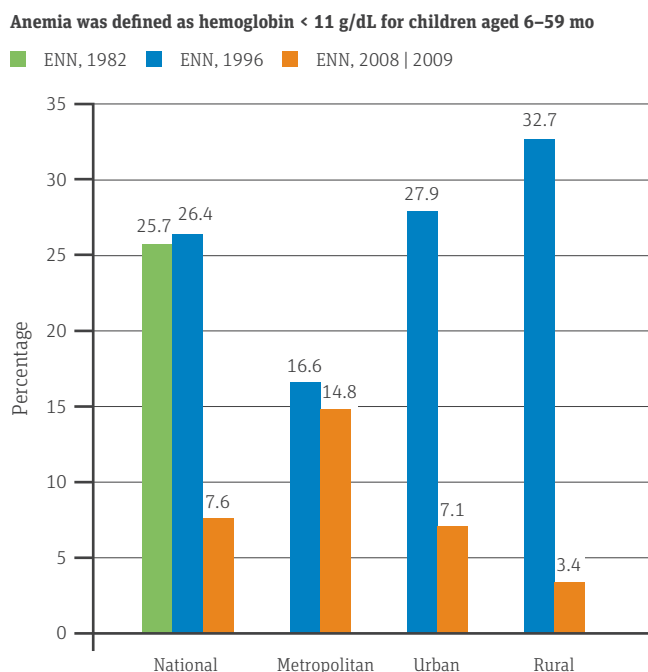
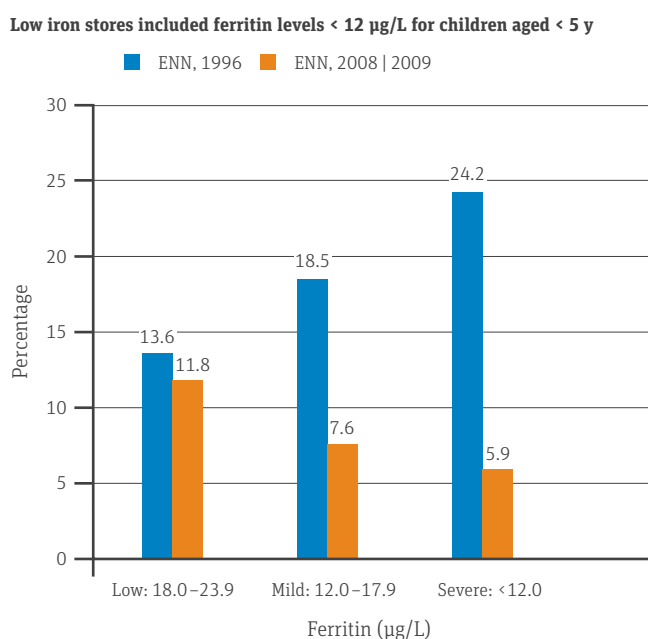


FIGURE 2: Prevalence of low ferritin in Costa Rican preschool children; 1996 compared to 2008–2009.



• Government leadership

Government leadership has been crucial to the establishment and implementation of the rice fortification program. The early success of other large-scale food fortification efforts and the existence of the government's cross-sector commission created an enabling environment for the passage of mandatory rice fortification legislation. The government worked in collaboration with the private sector to ensure sustainability. In addition, the government maintained the political will for legislative monitoring and enforcement, including incentives to reinforce compliance and punishments for non-compliance.

“Government leadership was crucial in establishing and implementing the rice fortification program”

• Sustainable partnership approach: engaging rice millers and leveraging existing distribution channels

The Costa Rican government worked in partnership with the private sector from the start of the program. Negotiations with the rice industry association were supported, and the private sector was given sufficient time to implement the mandatory fortification. Importantly, as the price of rice is controlled, the Ministry of Economy included the cost of fortification within the cost model in determining the wholesale and retail prices.

Millers and distributors leveraged the pre-existing channels to produce and distribute the fortified rice. Two private sector food companies manufacture the fortified kernels. The government helped to study the different premix options and costs, taking into account the market price. Based on the government analysis of the most efficient supply chain structure, fortified kernel producers invested in developing blending technology to be installed at the rice millers.

Costs and responsibilities were shared between public and private sectors

A significant portion of the cost to develop a rice fortification program was covered by the private sector, thus increasing the program's sustainability. The Ministry of Health financed the health needs research, while technology development was financed by the fortified kernel producers seeking profit opportunities. Two companies, Kuruba and DSM, led technology development and premix tests for the fortified kernels. The Institute of Nutrition of Central America and Panama (INCAP) led technology assessment and micronutrient stability tests. In addition, one of the fortified kernel suppliers supported the industry by investing in the development of blending technology. Advocacy for implementation of the mandate was led by the rice

FIGURE 3: Prevalence of anemia in Costa Rican women of childbearing age by area; 1982 and 1996 compared to 2008–2009.

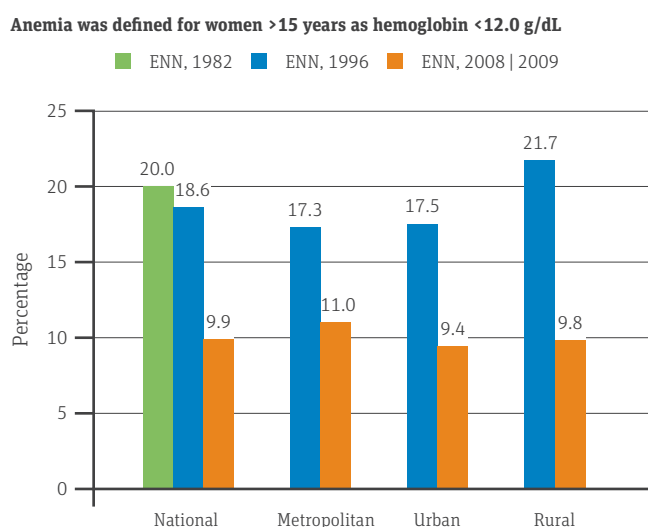
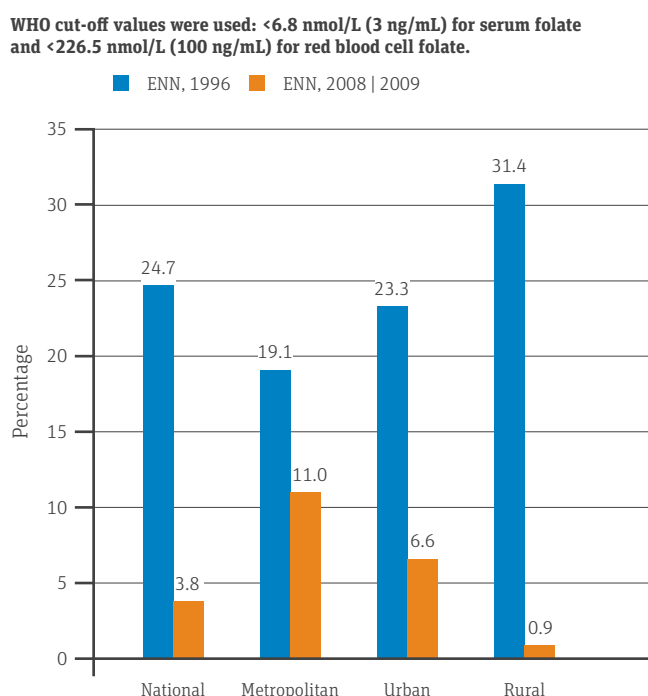


FIGURE 4: Prevalence of folate deficiency in Costa Rican women of childbearing age by area; 1996 compared to 2008–2009.



millers' association, ANINSA, and the national rice corporation, CONARROZ. These private and civic sector efforts helped ensure sustainability. The government's only costs to maintain the program are the laboratory equipment and labor necessary for on-going monitoring, evaluation, and quality-control activities.

Consumer prices were controlled

The Ministry of Economy Trade and Industry controls rice prices at the wholesale and retail levels, by accounting for the added cost of fortification. Demand for rice is relatively inelastic. As mentioned previously, initially retail rice prices rose by 5–6%. However, after more experience in production helped reduce costs, retail prices fell. The current retail price increase due to fortification is only 0.9%.

It is important to note that mandatory fortification eliminated the need to create consumer demand, which has proven difficult for fortified staples. For more information on lessons learned from flour and salt fortification, see the contribution by Kupka et al (pp. 68–72). Rice distributors are able to cover the minimal increase in their costs through the government-mandated price without the need to spend additional resources on marketing and consumer demand generation.

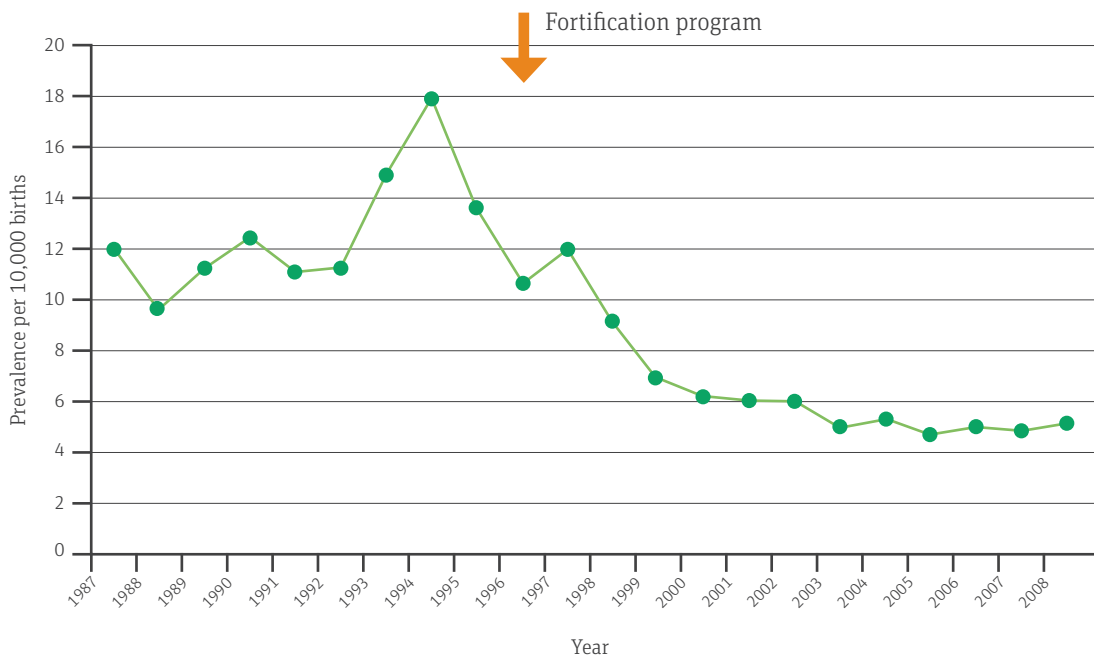
Good consumer acceptability

As consumers cannot tell the difference between Costa Rica's fortified and non-fortified rice, consumer acceptability is high. Tests showed that rice produced according to government standards can be washed without losing nutrients, and looks, smells and tastes the same as non-fortified rice.

“Costa Rica’s rice fortification program exemplifies successful implementation”

Conclusion

Costa Rica is a model for successful implementation of a rice fortification program. Program success is attributed to the country's experience with fortification of other commodities; the centralized rice industry; a good understanding of the rice industry landscape and supply chain; strong government leadership; early involvement and support from both private and public sectors; and a strong emphasis on the importance of monitoring and compliance. The government also monitored the positive public health impact of the fortification program. Costa Rica's experience demonstrates that, when feasible, mandatory fortification is a very cost-effective delivery option. Mandatory fortification eliminates the need for price-increasing marketing efforts and consumer awareness campaigns.

FIGURE 5: Birth prevalence of neural tube defects (NTDs) in Costa Rica; 1987–2008

Blending of fortified kernels with non-fortified rice at rice mill in Costa Rica

a technology, organizational and public health perspective, Costa Rica demonstrates that rice fortification can be implemented successfully, and can significantly contribute to the reduction of micronutrient deficiencies.

References

1. Ministerio de Salud. Encuesta Nacional de Nutricion: 2 Fasciculo Micronutrients (National nutrition survey: Part 2 Micronutrients). San Jose: Ministerio Salud, 1996
2. Barboza Arguello M de la P, Umana Solis LM. Impacto de la fortificación de alimentos con acido fólico en los defectos del tubo neural en Costa Rica (Impact of the fortification of food with folic acid on neural tube defects in Costa Rica). *Rev Panam Salud Publica* 2011;30:1–6.
3. Forsman C, Milani P, Schondebare JA et al. Rice fortification: a comparative analysis in mandated settings. *Ann N Y Acad Sci* 2014;1324:67–81.
4. Rodríguez S, Blanco A, Cunningham L et al. [Prevalence of nutritional anemia in women of reproductive age. Costa Rica. National nutrition survey, 1996]. *Arch Latinoam Nutr* 2001;51(1):19–24.
5. Costa Rica National Nutrition Survey 2008–2009 Accessed at: <http://ghdx.healthdata.org/record/costa-rica-national-nutrition-survey-2008-2009>. Accessed April 6, 2015.

Overall, the Costa Rican experience provides valuable lessons for implementing a successful rice fortification program. Although the rice milling landscape in many Asian countries is more fragmented, making implementation more complex, from

Case Study: Bangladesh

Hans Ebbing, Jennifer Rosenzweig
World Food Programme Regional Bureau for Asia

Rezaul Karim
World Food Programme Bangladesh

Country background and program description

With rice as the primary staple food, providing 70% of daily caloric intake for most Bangladeshis, and the high prevalence of micronutrient deficiencies in the country, rice fortification has the potential to improve micronutrient health in Bangladesh.

Bangladesh, the 8th most populated country in the world, is classified as a least developed country,¹ and ranks 142nd out of 187 countries on the Human Development Index.² Bangladesh is among the top ten global rice-producing countries, with an annual production of over 35 million metric tons in 2014.³ Both the export and import of rice in Bangladesh is minimal, with imports totaling less than half a million metric tons in 2014.³

Despite gains in reducing poverty,⁴ malnutrition and food insecurity remain critical, with sixty million people living below the poverty line of US\$1.25/day.¹ Among children aged 6–59 months, high levels of malnutrition persist, despite significant improvements in recent years, with 19% of young children estimated to be wasted, 30% underweight, and 32% stunted.⁵

In Bangladesh, micronutrient health indicators are poor. Subclinical vitamin A deficiency is high among preschool children (21%), and school-age children (21%). Anemia is also a public health concern, with 26% of non-pregnant and non-lactating women and 33% of preschool children anemic. With poor dietary diversity, rates of deficiencies in zinc, vitamin B₁₂, and folate are also of concern in women of reproductive age as well as in children.

Overview of rice fortification in Bangladesh

In 2011 an initiative was launched to make fortified rice available through the Bangladesh social safety net system. This was a collaborative effort between the Government of Bangladesh and the World Food Programme (WFP). The initiative built upon existing public and private partnerships and earlier efforts. This included a rice landscape analysis by the Global Alliance for

Improved Nutrition (GAIN) and DSM,⁶ and acceptability trials by PATH and the Bangladesh Rural Advancement Committee (BRAC).⁷

In the early phase of the initiative, rice fortification feasibility and acceptability trials were conducted among Vulnerable Group Development (VGD) program beneficiaries. These studies were conducted in partnership between the Government of Bangladesh, WFP, BRAC, and DSM. In addition, WFP arranged and facilitated a study tour to China mid-2013 to raise awareness and gain technical knowledge of fortified kernel production among government decision-makers, private sector representatives from the rice milling and garment sector, and WFP Bangladesh.

The VGD program, part of the government's social safety net program, was identified as an appropriate channel to reach with fortified rice populations most at risk of micronutrient deficiencies. The government-funded program reaches more than 3.75 million beneficiaries. It provides about 26 kg of rice or 30 kg of wheat per month to approximately 750,000 poor women for a two-year period after their enrolment.⁸

In 2013, the Government of Bangladesh, in partnership with the WFP, formally began the “Scaling Up of Rice Fortification in Bangladesh” project (the “project”). With funding from the Dutch Embassy in Dhaka, and critical seed funding from DSM, the project aims to reach 500,000 beneficiaries with fortified rice through the government safety nets and to establish a sustainable commercial market for fortified rice in Bangladesh by 2017. This goal is to mainstream fortified rice into the government's social safety net system, including the VGD program and the hot school meals program. The project also collaborates with the private garment sector to provide fortified rice to their female employees. By increasing distribution through the social safety net and advancing commercial demand for fortified rice, the project aims to reach economy of scale. Key elements are setting up sustainable domestic production of fortified kernels and installing blending equipment in rice mills and at large rice warehouses.

In the project's first phase, fortified rice was distributed to over 55,000 VGD beneficiaries in five upazilas (local sub-districts in the administrative structure) and approximately 19,000 school children through the hot school meal program. Four rice mills were equipped with blending facilities to pro-

duce the fortified rice with imported fortified kernels. In 2015, 200,000 beneficiaries will receive fortified rice through the VGD program and other WFP-supported government programs. In addition, a garment factory plans to provide fortified rice to some of its workforce and families in 2015. A domestic private sector partner has installed a hot extrusion production line for the production of fortified rice kernels; as of Q1 2015, two successful trial runs have taken place. Also, additional rice mills will install fortified rice blending facilities to respond to the growing demand.

“The project aims to reach 500,000 beneficiaries with fortified rice and to establish a sustainable commercial market for fortified rice in Bangladesh by 2017”

Important components of the rice fortification project in Bangladesh

1. Creating partnerships

1.1. Multi-sector approach engaging public and private sector partners

The success of rice fortification in Bangladesh necessitates a multi-sector approach uniting public and private sector partners with one common goal: to increase access to, and consumption of, fortified rice.

Government leadership and collaboration across multiple government departments

Government leadership has proven to be critical to the success of rice fortification in Bangladesh. Due to the structure of the Bangladesh government and the social safety net system, as well as the technical and regulatory requirements of fortification, multiple ministries and departments are part of the decision-making process. High-level officials within the government of Bangladesh facilitated inter-ministerial discussions. This included the Secretary of the Ministry of Food and Disaster Management and the Secretary of the Ministry of Women and Children Affairs, both of whom were identified early on as champions for rice fortification, and who took responsibility for government leadership. This resulted in strong government support and funding to underpin awareness building and extension of the geographic areas covered by the project.

Involvement of the private sector

A multitude of private-sector stakeholders are involved to raise

awareness and share technical knowledge regarding the benefits of rice fortification in the Bangladeshi market. Stakeholders include: miller organizations, large and medium-sized millers, food processing companies, and garment companies. The Dutch international company Royal DSM, which is active in the fields of health and nutrition,⁹ has been engaged in a public-private partnership with WFP since 2007.¹⁰ Through this global DSM-WFP partnership, WFP and DSM provide technical expertise, seed funding for start-up activities, and coordination between stakeholders. Another key partner is a private-sector company interested in expanding the production and accessibility of fortified rice, and actively working towards this goal.

1.2. Working in partnership with donors

Funding from the Dutch government through the Dutch Embassy in Dhaka was key for the start of the project. The project strategy was developed with close collaboration between WFP and the Dutch Embassy. Following the policy “From Aid to Trade,” the Embassy facilitated private-sector linkages and emphasized the importance of linking food security, nutrition objectives, and the private sector. These outreach efforts helped involve the garment sector, which mainly employs young women who are vulnerable to micronutrient deficiencies.

1.3. WFP’s commitment as key technical partner

WFP Bangladesh’s senior management is committed to rice fortification. This has been demonstrated by allocating resources to the formation of a dedicated multi-disciplinary technical team led by a project coordinator and anchored in the senior management structure. As of 2014, the five-member rice fortification team included technical experts in food handling, fortification, public health and nutrition, and public-private partnerships (the WFP project team). The WFP project team is collaborating closely with both public and private-sector partners.

2. Addressing commercial sustainability for fortified rice

The pricing of fortified rice in comparison with non-fortified rice affects its sustainability. The costs associated with imported fortified kernels and the project start-up created high fortification costs in the early phases of the project. Domestic production of fortified kernels has been a requirement from the start to reduce costs and ensure long-term sustainability. The government also considers domestic production necessary to meet demand and enhance business opportunities. It would have been challenging to convince the private sector to invest in kernel production and blending without an existing demand for fortified rice. In this respect, the government commitment to scale up the distribution of fortified rice through social safety nets and the recognized need to address micronutrient deficiencies were essential in encouraging private-sector interest and investment.

On the supply side: Starting in 2012, WFP promoted the concept, benefits and potential markets for fortified rice to companies identified as having the potential capacity and interest to install domestic production of fortified kernels. Discussions included detailing investment requirements and notification that WFP would not provide funding or co-financing. Initially, private-sector interest was quite low. Therefore, to showcase rice fortification in Bangladesh, a technical feasibility and acceptability trial were conducted in 2013, and a study tour of manufacturers and millers to China was organized. Although there was interest among large milling companies, the companies expressed concerns that the costs associated with establishing a production line were too risky in a new market area, that the business environment was difficult, and that the electrical infrastructure was not reliable. WFP also initiated discussions with other private food companies that had existing equipment (extruder, etc.) and a sophisticated production environment, such as electrical back-up or steam generation. As a result, by the end of 2014, one large food company joined the effort and installed a hot extrusion production line to produce fortified kernels with enough capacity to meet the current estimated demand.

On the demand side, the project created an initial market for fortified rice through the social safety net program, and is exploring the potential for commercial demand through voluntary fortification. This estimated demand secured the interest and commitment of a large food company in investing in micronutrient-kernel production in the second half of 2014.

3. Provision of high-quality technical assistance

Technical assistance was provided in setting the fortification standards, establishing blending facilities, conducting and analyzing research studies, design of communication strategies, and design and production of packaging.

To set fortification standards, the WFP project team – working with their government counterparts – proposed rice fortification standards based on existing wheat flour fortification standards. The government established a technical committee led by the Institute of Public Health Nutrition of the Ministry of Health. This committee proposed a national standard. Following a review, this national standard was approved by the Bangladesh Standards and Testing Institution in early 2015.

To set up blending facilities and train millers, the WFP project team provided the technical assistance to develop the specifications and installation process for locally produced blending equipment. Internationally available blending equipment was cost-prohibitive and required too much advance time for procurement and installation. Therefore, a less costly and faster local solution was developed, using domestic production of equipment for continuous blending. The WFP project team also

provided additional training to ensure correct blending, including testing of the homogeneity of blending at the defined 1% fortified kernels to rice ratio. It also provided training on the handling and storage of the fortified kernels and the fortified rice. A third-party quality control agent was hired and trained to monitor the production process and quality.

To design and conduct research studies, the WFP project team assisted with the planning and design of the acceptability, technical feasibility and effectiveness studies, which were conducted by BRAC.

To support branding and communication, the name “PushtiChal”, which means nutritious rice, was selected by the key stakeholders, and the project team assisted with packaging development and related communication campaigns.

Opportunities and challenges for scale-up of fortified rice

Although challenges remain, the outlook for rice fortification in Bangladesh is bright, based upon achievement of significant milestones:

Construction of large-scale super silos

The building of eight super silos with capacity of over 500,000 metric tons offers an opportunity for large-scale fortification of the rice distributed through the government’s social safety net system. Determining feasibility and economic viability for scale-up will require further discussions and planning by Government decision-makers and the private sector.

Investment by a large food processing company for the startup of a fortified kernel production line

Trial production took place at the end of 2014 and full production is planned for late 2015. The company will develop and market their own brand of fortified rice, targeting high-end consumers through supermarkets in urban areas. This private-sector marketing has the potential to increase awareness of fortified rice and to trigger other companies to also produce fortified rice. Increased competition and demand are expected to lead to a reduction in the production cost of fortified rice.

Upcoming communication and social mobilization campaign

A campaign is planned with the aim of increasing public awareness of the importance of a balanced diet and micronutrients and of stimulating increased consumer and private-sector interest in fortified rice. The communication strategy will also include dissemination of the results of the planned effectiveness trial.

Garment factory to provide fortified rice to its employees

Within the project timeframe and taking into account ethical as-

pects, a garment factory plans to distribute rice to 3,000 employees and their families to improve their health status. Although this is a relatively small program, this trial by a leading company may influence other private-sector companies. Other factories have already expressed an interest in the results of the project.

Monitoring and enforcement of the standard for fortified rice

Monitoring and enforcing compliance with the established standard for fortified rice is essential. However, the Bangladesh examples in the field of oil fortification or salt iodization indicate that monitoring may be problematic. The government must make investments to reinforce the capacity of the Bangladesh Standards and Testing Institution to ensure compliance with the standard, particularly as scale-up proceeds.

Conclusion

Introducing sustainable production of fortified rice requires a multi-stakeholder (various ministries, private-sector organizations, donors, technical partners) and multi-dimensional approach (technical, political, and business aspects). The WFP-supported, government-led rice fortification initiative in Bangladesh approached rice fortification using this strategy. The rice fortification initiative is based on the strong public-private partnership between the Government of Bangladesh, WFP, DSM, and private-sector partners in Bangladesh, and the catalyzing sponsorship of the Dutch Embassy. The development of the program began with extensive study of the rice landscape analysis, and steadily built leadership and partnerships, conducted trials, utilized technical expertise, addressed commercial sustainability, and fielded a strategic communication program.

“Introducing sustainable production of fortified rice requires a multi-stakeholder and multi-dimensional approach”

Therefore, in the relatively short time span of 2011 to 2014, fortified rice has been strategically and effectively introduced in Bangladesh. By the end of the current project (2017), the program plans to reach 500,000 beneficiaries through social safety net channels, and to introduce fortified rice commercially as voluntary fortification. Although these efforts will reach a large number of people, given the size of the Bangladeshi population (160 million) and the high prevalence of micronutrient deficiencies, further rice fortification scale-up is essential to achieve a significant public health impact.

References

1. World Development Indicators 2014. Washington, DC: World Bank. doi:10.1596/978-1-4648-0163-1. License: Creative Commons Attribution CC BY 3.0 IGO. Available from: <http://data.worldbank.org/sites/default/files/wdi-2014-book.pdf>.
2. United Nations Development Programme. Human Development Report 2014: Sustaining Human Progress: Reducing Vulnerabilities and Building Resilience [Internet]. New York: UNDP; 2014 [accessed January 31, 2015]. 225p. Available from: <http://hdr.undp.org/sites/default/files/hdr14-report-en-1.pdf>.
3. Food Planning and Monitoring Unit (FPMU). Bangladesh Food Situation Report: Volume-97 [Internet]. Dhaka: Ministry of Food; 2014 Jun [accessed January 31, 2015]. 6p. Available from: www.nfpcsp.org/agridrupal/sites/default/files/FSR_97.pdf.
4. General Economics Division. Perspective Plan of Bangladesh 2010–2021 [Internet]. Dhaka: Ministry of Planning; 2012 Apr [accessed January 31, 2015]. 100p. Available from: www.plancomm.gov.bd/wp-content/uploads/2013/09/Perspective-Plan-of-Bangladesh.pdf.
5. Institute of Public Health Nutrition. National Micronutrients Status Survey 2011–12 [Internet]. Dhaka: Ministry of Health and Family Welfare; 2014 Jun [accessed January 31, 2015]. 153p. Available from: www.icddr.org/publications/cat_view/10043-icddr-documents/10058-icddr-reports-and-working-papers/14275-survey-reports
6. Market study for analysis of Bangladesh Rice Industry, Sybiometrics Innovations Private Ltd., February 2011.
7. Barnali C, Mukta US, Majumder MSI et al. Pilot Study on Consumer Acceptance of Micronutrient Fortified Ultra Rice in Bangladesh [Internet]. Dhaka: BRAC; 2012 Dec [accessed January 31, 2015]. 22p. Available from: <http://research.brac.net/new/ebook/Publication/282-Consumer-Acceptance-of-Micronutrient-Fortified-Ultra-Rice-in-Bangladesh>.
8. Bangladesh Institute of Development Studies (BIDS). Impact Evaluation of Vulnerable Group Development (VGD) Program in Bangladesh [Internet]. Dhaka: Ministry of Women and Children Affairs (MWCA); 2012 May [accessed January 31, 2015]. 57p. Available from: http://bids.org.bd/files/VGD_final_report-19052012.pdf.
9. DSM – Bright Science. Brighter Living. Accessed at: <http://www.dsm.com/corporate/about.html>, on January 31, 2015.
10. DSM and UN WFP strengthen partnership to combat global malnutrition. Accessed at: www.dsm.com/corporate/media/informationcenter-news/2013/01/dsm-and-un-wfp-strengthen-partnership-to-combat-global-malnutrit.html, on January 31, 2015.



The Secretary of the Ministry of Women and Children Affairs, Tariq-ul Islam, and the WFP Representative in Bangladesh, Christa Räder, visit a fortified rice distribution site in Kurigram

Bangkok Rice Fortification Workshop

Delegations



Technical representatives shared their perspective, including the World Bank, the Asian Development Bank (ADB), the Government of the Kingdom of the Netherlands, the European Union (EU), the United States Agency for International Development (USAID) and the Australian Government Department of Foreign Affairs and Trade (DFAT)



Bangladesh delegation



Cambodia delegation



India delegation



Indonesia delegation



Laos delegation



Myanmar delegation



Nepal delegation



Philippines delegation



Sri Lanka delegation

Glossary

This glossary is based on the following sources:

Allen L, de Benoist B, Dary O et al, eds. Guidelines on food fortification with micronutrients. Geneva: World Health Organization | Food and Agriculture Organization of the United Nations, 2006.

UNICEF. Nutrition Glossary: A resource for communication. Division of Communication, 2012 [www.unicef.org/lac/Nutrition_Glossary_\(3\).pdf](http://www.unicef.org/lac/Nutrition_Glossary_(3).pdf) (accessed April 30, 2015).

Anemia

Characterized by reduction in hemoglobin concentrations or the size and color of red blood cells, which impairs the ability to supply oxygen to the body's tissues. Anemia is caused by inadequate intake and/or poor absorption or excessive losses of iron, folate, vitamin B₁₂ and other nutrients. It can also be caused by infectious diseases (inflammation) such as malaria, hookworm infestation and schistosomiasis, and by genetic variants of hemoglobin. Women and children are high-risk populations. Clinical signs include fatigue, pallor (paleness), breathlessness and headaches.

Bioavailability

Bioavailability refers to the proportion of a nutrient that is absorbed from the diet and utilized for normal body functions. The ease by which the body absorbs specific micronutrients is determined by its molecular form and the interaction between different specific micronutrients and other substances in the diet.

Biofortification

Practice of improving the nutrient content of plants before harvesting through breeding (e.g. new rice variety with higher iron content) and/or genetic engineering (e.g. Golden Rice). The key difference between biofortified rice and fortified rice is that rice fortification implies adding nutrients to rice post-harvesting, while biofortification aims to make more nutritious rice varieties available through breeding or GMO. While current biofortified rice cultivars contain higher levels of one micronutrient, fortified rice can contain a range of several micronutrients.

Blending

Mixing of milled, non-fortified rice with fortified kernels in ratios between 0.5% and 2% to produce fortified rice. Blending

can be done at a rice miller, warehouse, or other location where rice is centrally processed. Small-scale blending technology is also available.

Brown rice

Rice with only the hull removed. Bran layers and rice germ remain, giving the rice a brownish color. Brown rice is still a rich source of vitamins B₁, B₆, E and niacin, most of which are removed during polishing/milling.

Coating

Technology to make fortified kernels. Rice kernels are coated with a fortificant mix plus ingredients such as waxes and gums. The micronutrients are sprayed onto the rice grain's surface. The coated rice kernels are blended with non-fortified rice in a ratio between 0.5% and 2%.

Dusting

Technology to make fortified rice. Polished milled rice kernels are dusted with a fortificant mix in powder form. This technology is only used in the United States and does not allow for washing, pre-cooking or cooking in excess water, since this will wash out the micronutrients.

Effectiveness

Refers to the impact of an intervention in practice (real-life conditions). Compared to efficacy, the effectiveness of a fortification program will be limited by factors such as non-consumption or low consumption of the fortified food.

Efficacy

Refers to the capacity of an intervention such as fortification to achieve the desired impact under ideal circumstances. This usually refers to experimental, well-supervised and controlled intervention trials.

Essential micronutrient

Refers to any micronutrient (vitamin or mineral), which is needed for normal growth, development and function by the body in minuscule amounts throughout the life cycle. Micronutrients are normally consumed as part of a healthy and diverse diet. They either cannot be synthesized in adequate amounts by the body at all, or else cannot be synthesized in amounts adequate for good health. They thus must be obtained from a dietary source.

Estimated average requirements (EAR)

EAR is the average (median) daily nutrient intake level estimated to meet the needs of half the healthy individuals in a particular age and gender group.

Evaluation

Systematic assessment using criteria governed by a set of standards to help in decision-making. The primary purpose of evaluation, in addition to gaining insight into prior or existing interventions, is to enable reflection and assist in the identification of future change. For fortification programs, this means assessing the effectiveness and impact of the program on the targeted population, and to provide evidence that the program is achieving its nutritional goals.

Extrusion

Technology to make fortified kernels. Rice-shaped reconstituted kernels are produced by passing rice flour dough, containing a fortificant mix, through an extruder. The extruded kernels, which are made to resemble rice grains, are then blended into non-fortified rice in a ratio between 0.5% and 2%, similar to the coating technology. Extrusion allows for the use of broken rice kernels as an input, and may be carried out under hot, warm, or cold temperatures, which influences the appearance and performance of the final fortified kernel.

Fortificant

Selected essential micronutrient in a particular form to fortify selected food (e.g., rice, flour, salt).

Fortificant mix

Blend that contains several fortificants, also referred to as premix.

Fortification

Practice of deliberately increasing the content of essential micronutrient(s), i.e., vitamins and minerals, in a food, so as to improve the nutritional quality of the food supply and provide a public health benefit with minimal risk to health. The essential micronutrients are added to make the food more nutritious post-harvesting.

Fortification of rice distributed through social safety nets

Targeted rice fortification can be achieved by fortifying rice distributed through social safety nets, such as school feeding programs, distributions to the poor or vulnerable groups, food for work programs, and food aid during emergency situations. As social safety nets in most cases target the most vulnerable population groups, fortifying rice distributed through social safety nets will reach the most vulnerable populations and has great potential to make a significant impact on public health.

Fortified kernels

Fortified rice-shaped kernels containing the fortificant mix (extrusion) or whole rice kernels coated with a fortificant mix (coating). Fortified kernels are blended with non-fortified rice in a ratio between 0.5% and 2% to produce fortified rice.

Fortified rice

Rice fortified with fortificant mix by dusting, or non-fortified rice combined with the fortified kernels in a 0.5%–2% ratio. Typically fortified kernels are blended with non-fortified rice in 1:100 (1%) ratio.

Mandatory fortification

Mandated and regulated fortification of specific food commodities by the government sector through legislation. This means that all foods to which the legislation refers should be fortified according to the prescribed specifications.

Micronutrient deficiencies

A form of malnutrition caused by an insufficient intake of vitamins and minerals (also known as micronutrients), which are essential for human health, growth, development and function; also referred to as micronutrient malnutrition or hidden hunger. Micronutrient deficiencies are one of the main causes of poor health and disability, and affect over two billion people worldwide.

Micronutrient deficiency diseases

When certain micronutrients are severely deficient owing to insufficient dietary intake, insufficient absorption and/or sub-optimal utilization of vitamins or minerals, specific clinical signs and symptoms may develop, e.g., night blindness and xerophthalmia for vitamin A deficiency or rickets for vitamin D deficiency.

Milled rice

Polished rice is the regular milled white rice. Hull, bran layer and germ have been removed, and so have most of the vitamins. See also brown rice and parboiled rice.

Monitoring

Observing and checking progress or quality of a program over a period of time. For fortification programs it refers to the continuous collection and review of information on program implementation activities for the purposes of identifying problems (such as non-compliance) and taking corrective actions so that the program fulfils its stated objectives.

Non-fortified rice

Milled rice without fortification.

Nutrient requirement

Refers to the lowest continuing intake level of a nutrient that will maintain a defined level of nutrition in an individual for a given criterion of nutritional adequacy.

Parboiled rice

Rice that has been partially boiled in the husk. The three basic steps of parboiling are soaking, steaming and drying. Parboiling makes rice easier to process by hand, boosts its nutritional profile and changes its texture. Parboiling drives water-soluble nutrients from the bran to endosperm, hence parboiled white rice contains roughly half the water-soluble vitamins from brown rice, and is more nutritious than regular milled rice.

Quality assurance (QA)

Refers to the implementation of planned and systematic activities necessary to ensure that products or services meet quality standards. The performance of quality assurance can be expressed numerically as the results of quality control exercises.

Quality control (QC)

Refers to the techniques and assessments used to document compliance of the product with established technical standards, through the use of objective and measurable indicators.

Recommended nutrient intake (RNI)

RNI is the daily intake that meets the nutrient requirements of almost all apparently healthy individuals in an age- and sex-specific population group.

Regulatory monitoring

Comprises both internal and external monitoring; regulatory monitoring at the retail level is also referred to as commercial monitoring. The primary aim of regulatory monitoring is to ensure that the fortified foods meet the nutrient, quality and safety standards set prior to program implementation. Once regulatory monitoring has demonstrated that the program is operating in a satisfactory manner, evaluation of the program can be undertaken to assess its impact.

Tolerable upper intake level (UL)

Highest average daily nutrient intake level that is considered to pose no risk of adverse health effects to almost all (97.5%) apparently healthy individuals in an age- and sex-specific population group. The UL applies to daily use for a prolonged period of time for healthy individuals with no deficits to be corrected.

Voluntary fortification

A market-driven approach, with the fortified food product marketed as a “value-added” for the consumer. This approach relies on consumer awareness and education, demand, and willingness and ability to pay slightly more for the fortified product.

Imprint

Publisher: *Sight and Life* on behalf of
the World Food Programme

**Communication consultancy, text writing
and production management:**

Jonathan Steffen Limited, Cambridge, United Kingdom.
www.jonathansteffenlimited.com

Design concept, layout and graphics:

S1 Communication Design, Augsburg, Germany.
www.s1-buero.com

Printer:

Burger Druck, Waldkirch, Germany.
www.burger-druck.de

Sight and Life

Klaus Kraemer, PO Box 2116
4002 Basel, Switzerland

Phone: +41 61 815 8756

Fax: +41 61 815 8190

E-mail: info@sightandlife.org
www.sightandlife.org

World Food Programme

7th Floor Wave Place Building 55 Wireless Road,
Patumwan, Bangkok 10330, Thailand

Phone: +66 (0) 265 541 15

Fax: +66 (0) 265 544 13

E-mail: bangkok.riceworkshop2014@wfp.org
www.wfp.org

ISBN: 978-3-906412-78-8

Photo Credits

Front cover, first row, left to right:

© UNICEF/BANA2007-0759/Siddique

© UNICEF/INDA2011-00377/Vishwanathan

© UNICEF/BANA2010-00080/Haque

Front cover, second row, left to right:

© UNICEF/INDA2009-00271/Sampson

© UNICEF/INDA2010-00451/Feit

Front cover, third row, left to right:

© UNICEF/NYHQ2006-1823/Estey

© UNICEF/UKLA2013-04430/Lane

Page 05: © by Wenger

Page 06: WFP/Aditya Arya

Page 11: WFP/James Gambione

Page 16: PATH/Seema Kapoor

Page 30: WFP/Judith Smit

Page 36: WFP/Judith Smit

Page 42: PATH/Megan Parker

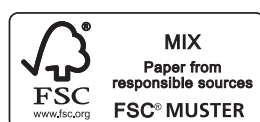
Page 44: WFP/Judith Smit

Page 78: © by ANINSA

Page 83: WFP/Cornelia Paetz

Page 84–87: Bangkok Rice Fortification
Workshop (Sept. 2014)

Carbon-neutral production



Sight and Life

PO Box 2116
4002 Basel, Switzerland

Phone: +41 (0) 61 815 8756

Fax: +41 (0) 61 815 8190

Email: info@sightandlife.org

www.sightandlife.org

World Food Programme

7th Floor Wave Place Building 55 Wireless Road,
Patumwan, Bangkok 10330, Thailand

Phone: +66 (0) 265 541 15

Fax: +66 (0) 265 544 13

Email: bangkok.riceworkshop2014@wfp.org

www.wfp.org