Scaling up Rice Fortification in West Africa

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Introduction

Now is the right time to scale up rice fortification in West Africa

Welcome to the third *Sight and Life* Rice Fortification Supplement, which focuses on the African continent, more specifically, the West African region. Following the previous supplements on Asia and Latin America, it is timely to take a closer look at the continent that has the largest *per capita* rice consumption after Asia yet where micronutrient deficiencies remain unacceptably high. This presents a significant opportunity for rice fortification. According to the 2016 Global Hunger Index (GHI) Africa Edition, despite a declining level of hunger across the continent since 2000, only three out of 42 countries in Africa have scores that fall into the 'low' hunger category, while 28 fall into the 'serious' category and five countries have scores in the 'alarming' category.[1]

Preventing micronutrient malnutrition

Micronutrient deficiencies are often referred to as 'hidden hunger' because they develop gradually over time, and their devastating impact is not seen until irreversible damage has been done. Globally, it is estimated that more than two billion people suffer from hidden hunger, caused largely by a dietary deficiency of vitamins and minerals. Deficiencies in essential micronutrients, such as vitamins A, D, and folic acid, and minerals such as iron, zinc and iodine, can have devastating health consequences ranging from serious physical and cognitive disabilities to life-threatening disorders. These adverse effects go hand in hand with low productivity and net economic losses for households, communities and nations. Yet, micronutrient malnutrition is entirely preventable. We know how to ensure optimal nutrition: a diverse diet and, where this is not possible, or else in the short term, interventions such as food fortification and micronutrient supplementation become critical. Staple food fortification is ranked by the Copenhagen Consensus 2012 as one of the highest-return interventions in global development and is endorsed by the 2008 and 2013 Lancet Series on Maternal and Child Nutrition and by WHO, WFP, UNICEF, FAO and the World Bank.

> "Micronutrient malnutrition is entirely preventable"

Not only are children's lives and futures at stake if we do not accelerate progress: failing to address micronutrient deficiencies has high costs in lost GDP and higher budget outlays. When children are properly nourished, they can grow up to be healthy and productive, helping to lift their communities and their countries out of poverty. 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 can thus significantly contribute to improved health and economic status in Africa.

Rice fortification in Africa

In Africa, fortification is making tremendous progress. Many countries fortify wheat and maize flour, cooking oil, sugar and salt as part of their comprehensive nutrition strategy. As the continent experiences a rise in economic growth and emerging common markets, regional bodies are also harmonizing fortification standards. This facilitates trade across country borders and has proven particularly effective in West Africa where multiple partners work together to enhance fortification efforts.

Rice fortification is the new conversation for furthering fortification in Africa. It is the enrichment of rice with essential vitamins and minerals post-harvesting to increase its nutritional value, and the potential for using rice as a vehicle to further increase the intake of missing essential vitamins and minerals is significant. Rice fortification has come a long way since the 1930s – while technological limitations hindered the scaling up of rice fortification for several decades, today, affordable technology exists to produce fortified rice kernels that look and taste like non-fortified rice. As Peiman Milani from *Sight and Life* explains on page 48 in this issue, the latest technology offers the benefits of rice fortification without requiring consumers to change any of their buying, cooking or eating habits.

Africa has the largest per capita rice consumption outside Asia. Of the 40.4 million metric tons (MMT) of rice globally traded in 2015–2016, 11.7 MMT were exported to Africa.[2] Rice is a growing key staple food in 19 African countries, especially in West Africa. In this region, the prevalence and impact of micronutrient deficiencies are significant, and anemia rates, vitamin A deficiency and iodine deficiency remain a public health concern. Fortified rice has the potential to reach 130 million people in 12 African countries, three-quarters of which are in West Africa.[3] To date, six countries worldwide have mandatory rice fortification legislation and most of the efforts are pilot projects or programs that provide free or subsidized food to selected populations. Mali has tested the operational feasibility of blending imported fortified kernels with local rice. Read about this innovative project on page 94, and about WFP's partner, the inspiring social entrepreneur Salif Romano Niang, on page 76.

Opportunities and challenges

This supplement is based on the presentations given at a two-day workshop, Rice Fortification – An Opportunity to Improve Nutrition in West Africa, which took place in Dakar, Senegal on November 27–28, 2017. This two-day event was organized by the UN World Food Programme (WFP) with the support of an Organizing Committee that included members from the UN Food and Agriculture Organization (FAO), the Food Fortification Initiative (FFI), the Global Alliance for Improved Nutrition (GAIN), Helen Keller International (HKI), Nutrition International (NI), *Sight and Life* (SAL) and the United Nations Children's Fund (UNICEF). It brought together high-level country delegates, global and regional technical partners and global and regional donors to raise awareness and discuss opportunities and challenges around rice fortification and its potential role in improving dietary quality and reducing micronutrient deficiencies in the West Africa region. Representatives from the following West African countries were present: Benin, Côte d'Ivoire, Gambia, Ghana, Guinea-Bissau, Liberia, Mali, Nigeria and Senegal. One representative from Madagascar also attended.

The articles in this supplement examine the current situation pertaining to micronutrient deficiencies in West Africa. They explore food availability and consumption in the region and review the status of, and the lessons learned from, grain fortification and its application in West African countries. The various contributions both explain the principles of rice fortification and present the latest evidence on rice fortification. The supplement helpfully elucidates some of the misconceptions associated with rice fortification and also investigates important considerations for identification of the most appropriate delivery channels and technologies for fortified rice. The significance of developing standards and the factors that influence the cost of rice fortification are also explained. A special article is dedicated to the new WHO guidelines on rice fortification and the supplement concludes with a summary of the West Africa Rice Fortification workshop.

We are grateful to the leading public health professionals who have contributed original articles as well as articles that initially appeared in, or were updated from, the supplements on Scaling Up Rice Fortification in Latin America published in 2017 and Scaling Up Rice Fortification in Asia published in 2015, in collaboration between *Sight and Life* and the WFP.

Now is the right time to scale up rice fortification in West Africa. The evidence base is sufficient; the feasibility and potential of scaling up is well documented and promising; and an increasing number of countries are interested and engaging with key stakeholders to make this a reality.

We invite you to join the discussion and hope this supplement will inspire you to become advocates for scaling up rice fortification in West Africa. **Join us on this journey.**

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The Critical Need to Address Malnutrition in Africa

Malnutrition remains an enormous challenge in Africa. Despite noteworthy progress, the number of stunted children under five continues to rise, with 58 million children affected. This trend is being met by the rising prevalence of overweight children and by other factors, such as changing food systems and urbanization, which make the achievement of Sustainable Development Goal (SDG) Target 2.2, "end all forms of malnutrition," more difficult.

Hidden hunger – a shortage of essential vitamins and minerals that is often unnoticeable to the naked eye – is one of the most pervasive kinds of malnutrition in Africa. Frequently, the people it affects don't show any clinical symptoms. However, while these micronutrient deficiencies may be invisible, their impact is even more pronounced. They increase susceptibility to infectious diseases, impair physical and mental development, reduce labor productivity and increase risk of premature death.

> "Globally, two billion people suffer from micronutrient deficiencies, likely affecting at least one-third of Africa's population"

Globally, two billion people suffer from micronutrient deficiencies, likely affecting at least one-third of Africa's population. Women and children from low-income families bear the brunt of this epidemic. For example, at least 20% of all women of reproductive age suffer from anemia in every African country. This rises to beyond 40% in some of the most affected countries.[1] Up to 37% of anemia is associated with iron deficiency; other causes include infections such as hookworm and malaria.

Failure to address anemia and other micronutrient deficiencies has generational effects, limiting the health, well-being and prosperity of families, communities and countries. Good maternal nutrition is crucial for early-life nutrition, with poor maternal nutrition having a direct effect on stunting. Economic losses associated with single micronutrient deficiencies can be up to 2% of gross domestic product (GDP), while losses due to stunting can reach up to 16.5% of GDP in African countries.[2] Despite these far-reaching effects, not a single country on the continent is on track to meet the World Health Assembly 2025 targets for anemia reduction.[3]

The necessity for robust action

This worrying situation demands urgent and robust actions for a dramatic change. If we are seriously committed to achieving the six targets set in the African Regional Nutrition Strategy and the African Union's Agenda 2063: The Africa We Want, then addressing malnutrition is critical for Africa to fully achieve the SDGs, given that progress in so many other sectors relies on good nutrition.

A key way to catalyze the change we need is by adding vitamins and minerals to fortify commonly eaten foods. In 2008, the Copenhagen Consensus ranked food fortification among the top three international development priorities as this intervention provides extremely high benefits by reducing micronutrient deficiencies at low cost. Every US$1 spent on fortification results in US$9 in benefits to the economy.[4]

Over the past century, fortification of staple foods has played a transformational role in reducing micronutrient deficiencies, starting in the 1920s to the 1940s in Europe and North America. However, one staple has been largely neglected: rice. Where rice is a staple food, micronutrient deficiencies remain widespread. Rice is a staple in 19 African countries, reaching an estimated 130 million people.[5] For rice consumers who do not eat sufficiently diverse diets, we see a tremendous opportunity to improve their micronutrient intake by providing fortified rice through social safety nets and school feeding programs, as well as through market initiatives.

The African Union (AU) and the World Food Programme (WFP) have both recognized the importance of food fortification to a future that is free from hunger and malnutrition. The

Schoolchildren in Liberia. WFP's nutrition work centers around promoting healthy diets that meet nutrient needs, especially of women and children.

Framework for African Food Security[6] – a constituent document of the framework of the Comprehensive Africa Agriculture Development Programme (CAADP) – includes micronutrient supplementation and food fortification among the immediate options for improving food utilization and dietary quality and diversity. The same framework also calls for promotion of technologies for the production and processing of nutrient-rich crops through inclusion in intermediate country-level plans. As explained above, being one of the major staple crops recognized in the 2006 Abuja Declaration on Food Security, there is a valid reason for rice to be targeted in food fortification efforts.

Therefore, current efforts by WFP and implementing partners that are committed to improving nutrition within the agriculture value chain are commendable and encouraged.

"The Africa We Want"

In addition to being important to the SDGs, food fortification is an aspiration under the implementation of the Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods, under the AU's Agenda 2063: The Africa We Want.[7] The AU Commission Department of Rural Economy and Agriculture included food fortification and biofortification under its first aspiration in the Malabo Operational and Business Plan 2017–2021, Sub-Program Area 3: Ending Hunger in Africa by 2025. The AUC works closely with WFP and other food security and nutrition global partners to scale up efforts for promoting biofortification on the continent while advocating rigorous advocacy for legislation on food fortification. Efforts are currently ongoing to advocate in favor of an AU decision on food fortification and biofortification.

WFP's nutrition work centers around promoting healthy diets that meet nutrient needs, especially of women and children. In many cases, this includes partnering with governments to define appropriate fortification legislation and policies, making fortified foods available in national social safety net programs and on local markets, and directly providing fortified foods to vulnerable populations that tend to have a higher risk of micronutrient deficiencies.

Building on experience from Latin America and Asia, rice fortification has also become a key focus for WFP in Africa. WFP is pioneering a new approach to local fortification of rice in Mali. The model involves procuring local rice and blending it with imported fortified kernels so that nutritious rice, grown by local farmers and blended by a local miller, can be provided in school meals. WFP is eager to partner with governments, the private sector and other key partners to develop similar solutions in more countries and to harness regional demand to work on rice fortification on a larger scale across the continent.

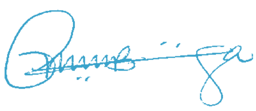
Achieving the SDGs demands a future where everyone can access diverse diets which include the various fruits, vegetables, animal-source foods, and staple foods needed to meet their specific nutrient needs. While remaining resolute in working towards such a future, options that can immediately improve diet quality – such as food fortification – must be embraced.

> "We believe that food fortification is a powerful means to reduce micronutrient deficiencies and improve overall health and well-being and, together with partners, we are committed to scaling up action for rice fortification"

We believe that food fortification is a powerful means to reduce micronutrient deficiencies and improve overall health and well-being and, together with partners, we are committed to scaling up action for rice fortification. We applaud the great work done by all who contributed to producing this *Sight and Life* supplement and hope it will be a helpful resource that will inspire you to join the movement to champion and scale up rice fortification across Africa.

The organizing committee

A special thank you goes to the members of the organizing committee: Sarah Zimmerman (FFI), Scott Montgomery (FFI), Greg Garrett (GAIN), Fred Grant (HKI), Noel Zagre (UNICEF), Noor Khan (NI), Mawuli Sablah (FAO), Klaus Kraemer (*Sight and Life*), Kesso Gabrielle van Zutphen (*Sight and Life*), Anna Horner (WFP), Penda Toure (WFP), Fadoi Chaouki (WFP), Priscila Porto (WFP), Jane Badham (JB Consultancy) and Dora Panagides (WFP).



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A schoolgirl in Cape Verde. Achieving the SDGs demands a future where everyone can access diverse diets.

Current Situation of Micronutrient Deficiencies in West Africa

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Community health worker distributing micronutrients to children under the age of five in Senegal, 2015

Introduction

Micronutrient deficiency refers to inadequate levels of vitamins and minerals in the human body. It is one of the significant public health issues worldwide. Deficiency of iron, folic acid, iodine, vitamin A and zinc are the most common micronutrient deficiencies, and can lead respectively to anemia, neural tube defects, cognitive impairment, morbidity and mortality.

Iron deficiency and resulting anemia affect more than 3.5 billion people in the developing world and iron deficiency impairs the cognitive development of children, causes productivity and educational losses, and increases morbidity and maternal mortality.[1]

Globally, 68% of households in countries with iodine deficiency disorders (IDD) currently consume iodized salt.[2] By establishing and sustaining national salt iodization schemes and forging effective partnerships between United Nations agencies, national and international nongovernmental organizations and the salt industry, great progress has been made in recent years toward the elimination of iodine deficiency, the most common cause of preventable mental impairment worldwide.

A vitamin A supplement being given to a child under the age of five

Although severe vitamin A deficiency is declining, subclinical deficiency still affects up to 190 million preschool children.[3] Many more school-age children, pregnant women and others are affected. Vitamin A deficiency contributes significantly to raised morbidity and mortality in at-risk populations. Effective, low-cost approaches to the control of vitamin A deficiency are available and are being applied in many countries.[4]

West Africa has a population of close to 372 million people, of whom 62.3 million are children under five years of age. Over one-third of these – 19 million – are stunted. Nearly half of all women of reproductive age (49%) have anemia, and 47% of children aged 6–59 months have vitamin A deficiency.[5]

The existence of a single economic community in the region – the Economic Community of West African States (ECOWAS) – offers opportunities to align regional strategies and policies to tackle malnutrition collectively. This article provides the most updated status of micronutrient deficiencies in West Africa,

TABLE 1: National surveys in West Africa that include data on micronutrient status at population level

Country	Year of Survey	Survey
Benin	2011–2012	Benin Demographic and Health Survey
Burkina Faso	2010	Burkina Faso Demographic and Health Survey – MICS
Cape Verde	2005	Inquérito Demográfico e de Saúde Reprodutiva (IDSR-II)
Cote d'Ivoire	2011–2012	Cote d'Ivoire Demographic and Health Survey – MICS
The Gambia	2013	The Gambia Demographic and Health Survey
Ghana	2017	Ghana Micronutrient Survey 2017
Guinea	2012	Guinea Demographic and Health Survey – MICS
Guinea-Bissau	2012	Food Fortification Initiative http://ffinetwork.org/country_profiles/
Liberia	2013	Liberia Demographic and Health Survey
Mali	2012–2013	Mali Demographic and Health Survey
Niger	2012	Niger Demographic and Health Survey – MICS
Nigeria	2013	Nigeria Demographic and Health Survey
Senegal	2016	Senegal Continuous Demographic and Health Survey
	2010–2011	Senegal Demographic and Health Survey – MICS
Sierra Leone	2013	Sierra Leone Demographic and Health Survey
Togo	2013–2014	Togo Demographic and Health Survey

along with actions taken to combat them. Attention is also drawn to the Ghana Micronutrient Survey 2017, which was published in 2018 while the present publication was under development.

"Although severe vitamin A deficiency is declining, subclinical deficiency still affects up to 190 million preschool children"

Methods

The databases available on micronutrient deficiencies were accessed to search for the latest Demographic and Health Surveys (DHS) for each West African country. This information was complemented by the data collected from published and unpublished reports by many international NGOs working in the field of nutrition. We also reviewed other relevant documents that contain information not found in the sources above, such as certain documents from UN agencies (WHO, UNICEF, etc.).

Anemia was used as a proxy for iron deficiency and diarrhea prevalence for zinc deficiency. However, less than 50% of anemia can be attributed to iron deficiency. The categorization of the public health problem presented by the deficiency of each micronutrient was defined according to the following cut-off points in prevalence and range according to international recommendations:

Anemia[6]: no problem ≤ 4.9%, mild 5%–19.9%, moderate 20%–39.9%, severe ≥40%

Vitamin A deficiency[7]: no problem < 2%, mild ≥2% to < 10%, moderate ≥10% to <20%, and severe ≥ 20%

Iodine deficiency: no problem 100–200 µg/L, mild 50–99 µg/L, moderate 20–49 µg/L, severe <20 µg/L

Zinc deficiency[8]: no problem < 20%, problem >20%

Fifteen DHS and studies conducted between 2000 and 2017 were found (**Table 1**) that reported data on the nutritional status of iron (anemia), zinc, vitamin A, and iodine in women of reproductive age (**Table 2**) and children under five years old (**Table 3**). Some data for Guinea-Bissau were found on the FFI website.

Results

Prevalence of micronutrient deficiencies in West Africa

a. Iron: Anemia, especially due to iron deficiency (IDA), is the most common micronutrient deficiency in the West Africa region, especially among children under five and women of reproductive age. It is estimated that 38%–62% of women of reproductive health in the region suffer from iron deficiency anemia. Only Cape Verde has made progress, with anemia in women of reproductive age being a moderate public health problem. In the 14 remaining countries, anemia in women of reproductive age is a serious public health problem, with all prevalence rates above 40%. The prevalence ranged from 52% to 88% among children under five, and it is a severe public health issue in all West African countries.

Iron supplementation is a relatively inexpensive intervention to treat and prevent anemia related to iron deficiency. For-

TABLE 2: Prevalence of micronutrient deficiencies and magnitude of public health problem in children under five years of age in West African countries, with representative data

Public health problem	Iron deficiency (prevalence of anemia)		Urinary iodine excretion (median)		Zinc deficiency (prevalence of diarrhea)		Vitamin A deficiency (prevalence of serum retinol <0.70 µmol/L in preschool-age children)	
			Benin*	318	Sierra Leone	6%		
			Cape Verde*	115	Benin	6%		
			Cote d'Ivoire*	203	Mali	7%		
			Liberia**	254	Nigeria	10%		
			Ghana**	184	Cape Verde	11%		
			Guinea*	139	Ghana	12%		
No			Nigeria*	130	Niger	14%		
			Sierra Leone**	176	Togo	15%		
			Togo*	171	Guinea	16%		
					Burkina Faso	16%		
					The Gambia	17%		
					Cote d'Ivoire	18%		
					Senegal	18%		
			Mali*	69	Liberia	22%	Cape Verde	2%
Mild			Burkina Faso**	74				
			Niger**	82				
			Senegal**	80				
Moderate			The Gambia	42				
	Benin	58%					Benin	71%
	Burkina Faso	88%					Burkina Faso	54%
	Cape Verde	52%					Cote d'Ivoire	57%
	Cote d'Ivoire	75%					The Gambia	64%
	The Gambia	73%					Ghana	76%
	Ghana	66%					Guinea	46%
Severe	Guinea	77%					Guinea-Bissau	55%
	Guinea-Bissau	71%					Liberia	53%
	Liberia***	72%					Mali	59%
	Mali	82%					Niger	67%
	Niger	73%					Nigeria	30%
	Nigeria ***	71%					Senegal	37%
	Senegal	66%					Sierra Leone	75%
	Sierra Leone	80%					Togo	35%
	Togo	70%						

* General population data

** Pregnant women data

*** Data collected from WHO, the Global Prevalence of Anemia in 2011

tification with iron could be undertaken with a variety of food vehicles such as processed cereals, rice, salt and infant foods.

b. Iodine deficiency disorders: The prevalence of IDD is less compared to iron deficiency anemia. Iodine deficiency is not a public health issue for most West African countries (Benin, Côte d'Ivoire, Cape Verde, Liberia, Ghana, Guinea, Nigeria, Sierra Leone and Togo) and is rather excessive in Benin, Côte d'Ivoire and Liberia. However, the problem is of public health significance in some non-salt-producing countries, where it ranges from mild (Mali, Burkina Faso, Niger and, paradoxically, in Senegal, which produces and exports salt) to moderate (in The Gambia). The urinary iodine concentration ranged from 42 µg/L to 318 µg/L.

TABLE 3: Prevalence of micronutrient deficiencies and magnitude of public health problem in women of reproductive age in West African countries, with representative data

Public health problem	Iron deficiency (prevalence of anemia)		Prevalence of iodine deficiency (urinary iodine excretion)	Zinc deficiency (prevalence of diarrhea)	Vitamin A deficiency (prevalence of serum retinol <0.70 µmol/L in pregnant women)	
No			No data available	No data available	Nigeria	2%
Mild						
	Cape Verde	38%			Benin	18%
					Burkina Faso	17%
					Cote d'Ivoire	19%
					Ghana	18%
					Guinea	19%
Moderate					Guinea-Bissau	18%
					Liberia	12%
					Mali	17%
					Niger	15%
					Senegal	19%
					Sierra Leone	18%
					Togo	20%
	Benin	41%			Cape Verde	21%
	Ghana	41%			The Gambia	34%
	Sierra Leone	42%				
	Niger	44%				
	Guinea	45%				
	Togo	48%				
Severe	Liberia*	49%				
	Nigeria*	49%				
	Mali	50%				
	Cote d'Ivoire	52%				
	Senegal	56%				
	The Gambia	58%				
	Burkina Faso	62%				
	Guinea-Bissau	44%				

* Data collected from WHO, the Global Prevalence of Anemia in 2011

The major control methods for IDD are fortification of salt with iodine compounds, and distribution of adequately iodized salt. The cost of iodized salt is about US$0.05 per person per year.[9]

c. Zinc deficiency: Data on zinc deficiency in the West African countries are scarce and few countries include serum zinc levels as a proxy in their national nutrition surveys. Zinc deficiency is the result of inadequate dietary intake, malabsorption, increased losses, and/or barriers to its utilization. This results in growth retardation, hypogonadism, immune dysfunction and cognitive impairment. However, studies on dietary habits of children under five revealed low dietary intake of zinc ranging from 22% (Liberia) to 6% (Sierra Leone) in countries where data are reported.

d. Vitamin A deficiency: Vitamin A deficiency is also very important in terms of public health implications worldwide. It can lead to a weakened immune system, growth retardation in children, xerophthalmia, an increase in the burden of infectious diseases and an increase in the risk of death. Worldwide, vitamin A deficiency affects 190 million preschool children and 19.1 million pregnant women.[7]

All West African countries have serious vitamin A deficiency for children under five years old. The prevalence of this deficiency varies from 30% (Nigeria) to 75% (Sierra Leone).

National micronutrient delivery platforms

Table 4 describes micronutrient supplementation and fortification programs that are currently implemented at national level

Salt iodization in Ndiemou, Fatick Region, Senegal, with small-scale producers, 2018

in West African countries, and the number of countries that have adopted each of these strategies.

All West African countries (100%) have implemented vitamin A supplementation programs either through routine programming or individual campaigns, while 80% have iron and folic acid supplementation programs and 73% have zinc supplementation programs for diarrhea treatment.

Two-thirds of West African countries (64%) are implementing universal fortification programs. The range varies depending on the micronutrients and food vehicle used. More than three-quarters of the countries (80%) have established salt iodization programs, while almost all (93%) fortified wheat flour with iron and folic acid alone or combined with zinc and B vitamins. Vegetable oil is fortified with vitamin A by 87% of the countries. Maize fortification is, however, very low. Only Côte d'Ivoire and Nigeria fortify maize, although in the absence of any legislation.

> "Recent years have witnessed substantial progress in the struggle against micronutrient deficiencies in West Africa, but momentum may be slowing"

Conclusion

Recent years have seen some remarkable achievements and witnessed substantial progress in the struggle against micronutrient deficiencies in West Africa. But there are some signs that the momentum may be slowing as the path steepens. It is now, when micronutrient deficiencies can fairly be said to be a regional issue, that action needs to be taken to put in place the policies and interventions that will sustainably protect the regional population. The challenge is therefore clear and when so much could be achieved for so many and for so little, it would be a global disgrace if micronutrient deficiencies were not brought under control in the years immediately ahead.

Launch of the Zinc Alliance for Child Health (ZACH) for child diarrhea management in Touba Toul, Senegal, February 25, 2013

TABLE 4: National programs that provide micronutrients in West Africa, as reported by countries (*n*=15)

Program	Target group	No. of countries	Countries (% coverage)
SUPPLEMENTATION			
Vitamin A supplementation for children under five	15	15 (100%)	Benin (95%), Burkina Faso (97%), The Gambia (91%), Ghana (100%), Guinea (93%), Guinea-Bissau (100%), Liberia (100%), Mali (80%), Niger (89%), Nigeria (77%), Senegal (85%), Sierra Leone (91%), Togo (77%)
Prenatal iron and folic acid supplementation	15	12 (80%)	Benin (28.6%), Burkina Faso (97%), The Gambia (91%), Ghana (100%), Guinea (93%), Liberia (21%), Mali (18.3%), Niger (28.6%), Nigeria (20.5%), Senegal (62.6%), Sierra Leone (30%), Togo (77%)
Zinc supplementation for diarrhea treatment	15	11 (73%)	Benin (9.6%), Burkina Faso (0.4%), Cape Verde (21.1%), Guinea (0.5%), Liberia (3.1%), Mali (2.1%), Niger (10.3%), Nigeria (2.3%), Senegal (6.8%), Sierra Leone (3.8%), Togo (0.1%)
Universal food fortification			
Salt (iodine)	15	12 (80%)	Benin (72%), Burkina Faso (22%), The Gambia (8%), Ghana (50%), Guinea (60%), Guinea-Bissau (1%), Mali (74%), Niger (15%), Nigeria (98%), Senegal (16%), Sierra Leone (23%), Togo (67%)
Wheat flour	15	14 (93%)	Mandatory for 14 countries except The Gambia, where there is no industrial fortification
Vegetable oil	15	13 (87%)	Mandatory for 12 countries, voluntary for Mali, and no industrial fortification in Cape Verde and The Gambia
Maize flour	15	2 (13%)	Cote d'Ivoire and Nigeria

While some new data are presented, there remains a great need for nationally representative data on the prevalence and trends in micronutrient deficiencies in West Africa to inform and improve policy and program decisions.

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Schoolchildren on a school trip to Lac Rose to see the iodization of salt

Are there Potential Risks from Rice Fortification with Iron?

Commentary

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Rice fortification as a public health strategy

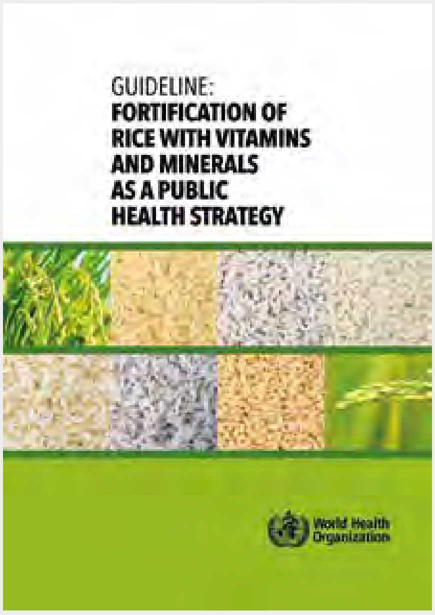
There is no doubt that food fortification is an effective public health nutrition strategy to prevent micronutrient deficiencies at the population level. Rice is a common staple food in many African countries and is well suited for fortification because it is widely consumed and acceptable.[1] Further, rice fortification is not limited to iron. Fortification of rice with multiple micronutrients has potential benefits beyond the reduction of micronutrient deficiencies. For example, fortification of rice with other micronutrients (e.g., vitamin A or zinc) can also benefit erythropoiesis and prevent anemia.

Authors of a systematic review (updated in 2017, including 16 studies) summarized the evidence on the efficacy of rice fortification:[2]

- Fortification of rice with iron (alone or in combination with other micronutrients) probably improves iron status by reducing iron deficiency (nine studies, moderate-certainty evidence) but may make little or no difference to the risk of anemia (seven studies, low-certainty evidence).
- Fortification of rice with other micronutrients (vitamin A or folic acid) may reduce vitamin A or folate deficiency (five studies, low-certainty evidence and one study, very-low-certainty evidence, respectively).
- Fortification of rice with iron (alone or in combination with other micronutrients) may increase hookworm infection (one study, low-certainty evidence).

This evidence has supported the development of the 2018 WHO recommendations for rice fortification as a public health strategy (**Figure 1**).

FIGURE 1: Global WHO recommendations for rice fortification (2018)



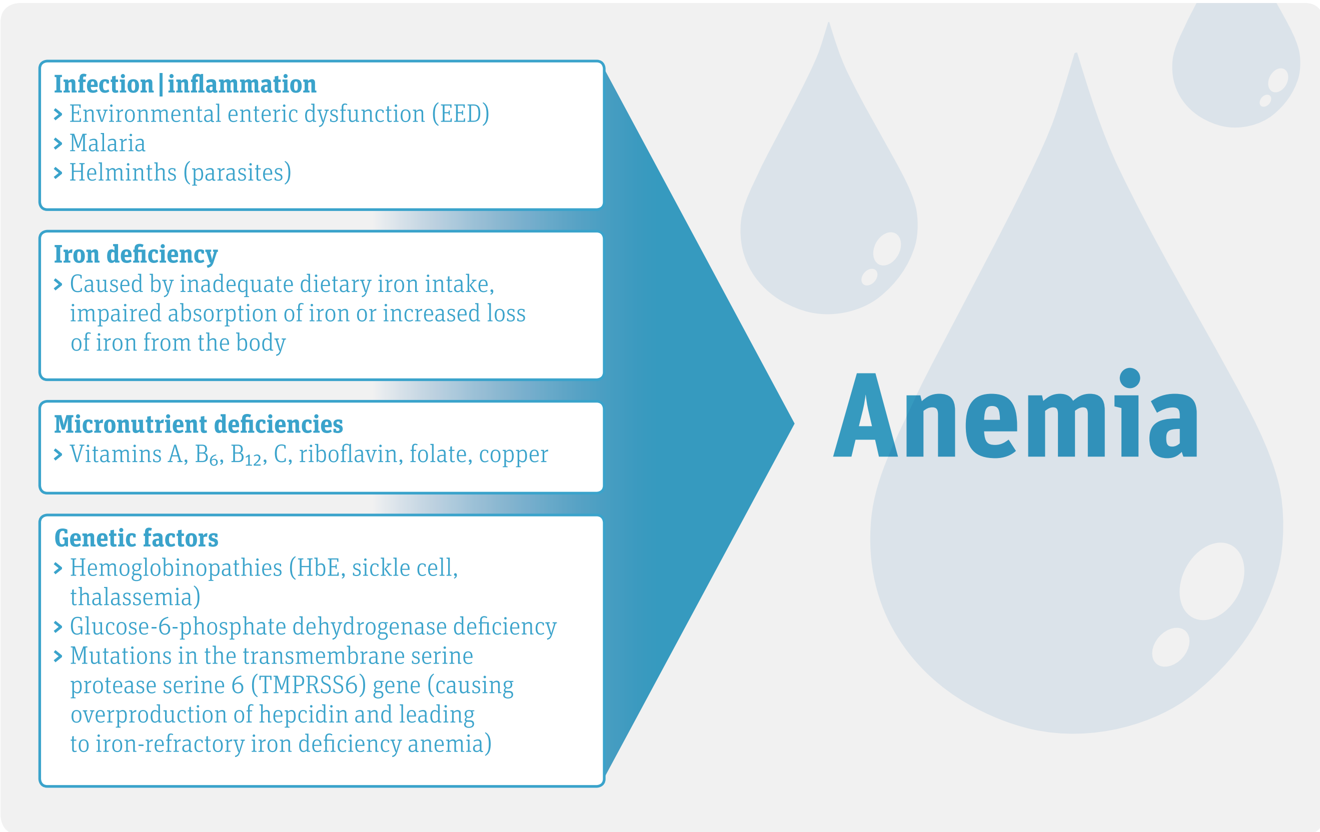
In 2018, WHO released a guideline on fortification of rice as a public health strategy

Emerging concerns regarding excess iron

However, concerns have emerged as to whether or not there is potential harm regarding the risk of excess iron in some populations, particularly in iron-replete individuals or among those with genetic hemoglobinopathies and/or infections such as malaria, pneumonia, or diarrhea.

Rice fields outside of Dili, Timor-Leste

FIGURE 2: Potential causes of anemia



Iron is an essential mineral in the body. It is required for oxidative energy metabolism, erythropoiesis and oxygen transport, as well as other important functions. Iron deficiency is associated with an increased risk of adverse health outcomes, especially in infants, children and pregnant women. However, at the same time, iron is potentially harmful, especially in the presence of oxygen, as it catalyzes the formation of highly reactive oxygen species via the Fenton reaction. Excess iron can cause intestinal injury, oxidative stress, DNA and cellular damage (e.g., DNA strand breaks) and increased susceptibility to pathogen growth.[3,4,5]

> "Iron is an essential mineral in the body. However, at the same time, iron is potentially harmful, especially in the presence of oxygen"

Preparation of rice in a WFP school feeding site in Rwanda

We highlighted these concerns in a recent *Sight and Life* magazine article – "Iron supplementation in iron-replete populations: Is there an emerging concern?"[6] We cited several recent surveys across Africa that showed low prevalence rates of iron deficiency among women and children. Rather than iron deficiency, genetic hemoglobinopathies (e.g., sickle cell disease) and infection (e.g., malaria) are common in many African countries and can be major contributors to anemia. If iron deficiency is not the cause of the anemia then, at best, iron interventions are a waste of resources and, at worst, they may cause harm. Thus it is imperative to determine the major causes of anemia in a population in order to develop appropriate and effective public health strategies to prevent, reduce and treat anemia.

The potential harm of rice fortification with iron

Consumption of iron-containing micronutrient powders have shown some potential for adverse effects in infants and children. In recent studies in Kenyan children, provision of micronutrient powders including iron (12.5 mg iron as ferrous fumarate) showed increased abundances of enteropathogens (including *Shigella, E. Coli* and *Clostridium*) and increased gut inflammation (increased fecal calprotectin concentrations), as compared to the same micronutrient powder without iron.[7] We highlight that novel ways to mitigate the adverse effects of iron-containing micronutrient powders on the gut microbiota have since been proposed, such as the inclusion of prebiotic galacto-oligosaccharides to micronutrient powders.[8] These promising approaches require further research.

> "We speculate that rice fortification would have a lower potential for harm as compared to other iron interventions"

We speculate that rice fortification would have a lower potential for harm in iron-replete individuals and populations with a higher burden of infectious disease, as compared to other iron interventions such as oral iron supplementation or home fortification with iron-containing micronutrients. This is because the doses of daily iron are typically lower and the consumption of the iron fortificant is limited to the amount of rice an individual can consume. In addition, the iron is incorporated in the food matrix, which reduces the potential for non-transferrin-bound iron accumulation in the blood.

Lastly, fortified rice can be one of multiple iron interventions in a population and this needs to be assessed at the time of program design and implementation in order to minimize the risk of excess iron intake.

Conclusion

The efficacy of rice fortification likely varies by population and context, and also depending on the proportion of anemia that is due to iron deficiency rather than other causes. The potential harm of rice fortification is expected to be low, given the low daily dose of iron and the limit of how much rice can be consumed by an individual. More research is needed to ascertain if there is potential harm presented by iron-fortified rice (or excess iron) and if this harm translates to adverse outcomes of biological or clinical significance.

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Food Availability and Consumption

Africa Integrated Rice Fortification

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Introduction

Effective and sustained food fortification programs contribute to improving micronutrient status of vulnerable populations when the fortified foods are consumed regularly and the levels of micronutrients added to those foods are based on the estimated average daily per capita intakes of the foods. The adequately fortified food must be consumed consistently by the vast proportion (est. >80%) of the population. Therefore, up-to-date data on intakes of the target foods to be fortified are essential for setting national fortification standards. In sub-Saharan Africa the diets of vulnerable populations are usually monotonous. Most cereal milling processes remove much of the intrinsic micronutrients. These should be restored and increased proportionately: the addition of extra vitamins and minerals will help to improve micronutrient intakes and status.

> "It is important to enhance the micronutrient value of widely consumed cereal-based staple foods to sustainably address micronutrient deficiencies in Africa"

It is important to enhance the micronutrient value of widely consumed cereal-based staple foods such as wheat and maize flours and rice to sustainably address micronutrient deficiencies in Africa. This paper seeks to provide an estimate of the availability and consumption of diverse food vehicles in Africa. There is a particular focus on rice as one of the key food vehicles for fortification with vitamins and minerals. The paper looks at subregional disparities in the availability and consumption of food as well as variations in per capita consumption in order to assist in aligning recommendations on rice fortification in Africa with recent WHO guidelines.[1]

Outlook for internally- and externally-sourced rice for consumption as a staple

The consumption of rice has been increasing significantly in Africa and has overtaken the consumption of major local cereals such as maize, sorghum and millet. In 2017 estimates from the Food and Agriculture Organization of the UN (FAO) for rice production in Africa exceeded the previous 2016 all-time high by 1% to reach 31.1 million tons (20.3 million tons milled basis).[2] This level was estimated to be sufficient to keep global per capita consumption largely steady at an estimated 54.3 kg per person per year. The FAO forecast for world rice inventories at the end of the 2017 and 2018 marketing seasons points to global reserves modestly increasing by half a percentage point year on year to reach 170.8 million metric tons.[3] In terms of imports, Africa witnessed an estimated 16 million tons of rice delivered in 2017, with the forecast easing slightly in 2018 to 15.6 million tons.[4] The increasing growth in demand for rice would continue to imply imports are outstripping local production gains. Burkina Faso, Cameroon, Guinea-Bissau, Mauritania, Niger and South Africa will all increase rice imports in 2018.[5] However, the rice sector in West Africa remains at the center of expansion through government and private-sector-supported initiatives. For West Africa, a yield turnover of 16 million tons (10.2 million tons milled basis) was projected in 2017, an increase of more than 4% over 2016 figures. Nigeria remains the lead producer and also importer of rice in West Africa, with 3.2 million tons estimated milled basis for 2017 – 6% over the yield for 2016. Marketing year estimates for 2018–2019 total imports for some key countries in the region – Burkina Faso, Guinea, Mali, and

Senegal – are expected to increase by approximately 14.5% to reach 3.375 million tons. Overall imports for 2017 stood at 14.5 million tons for the region – a 4% increase over 2016 estimates. Côte d'Ivoire, The Gambia, Liberia, Mauritania, Senegal and Togo all increased imports of rice to meet consumption needs.[6]

Potential effect of fortified rice consumption in Africa, in particular West Africa, relative to other foods

The following steps are recommended to implement an effective and sustainable mass food fortification program:

1. Define the target population(s)
2. Assess the intake and status of critical micronutrients and intake of potential food vehicles in the target population
3. Select the food vehicle(s)
4. Select the fortification compound
5. Determine the level of fortification
6. Establish the regulatory parameters
7. Estimate costs and establish financial/technical support
8. Develop a monitoring and evaluation plan

One of the key tools for measuring the frequency and adequacy of consumption as well as the feasibility of fortifying a potential food vehicle is the fortification rapid assessment tool (FRAT).[7] Dietary intake should be estimated as closely as possible for potential per capita consumption.[8]

FRAT serves as a pragmatic tool for confirming that the food vehicle is being consumed and to estimate the amounts and likely population coverage, and for determining the levels of micronutrient to be provided through fortification of the food.[9] Rice has not been a key food vehicle included in most FRAT surveys conducted in Africa, so this study used estimated per capita data from FAO statistics.[10] The present analysis only tracked the potential annual per capita consumption profile for rice and other foods using data from FAO. It made comparisons among different subregions and the potential contribution of rice fortification to improving micronutrient nutrition. However, future FRAT surveys should include rice and assist with establishing more refined per capita consumption profiles for planning rice fortification initiatives within specific contexts. This would complement previous FRAT surveys reviewed by Hess et al (2013) for 11 countries in Africa.[11] The median amount of wheat flour consumed, for example, ranged from 49 to 108 g/d among consumers in eight countries. The lowest amounts were reported in rural strata in Burkina Faso (21–53 g/d).[11] The data on wheat flour consumption correlated positively with data from FAO food balance sheets which enabled the establishment of adequate consumption ranges based on WHO guidelines and recommendations[12] for developing harmonized standards on wheat flour fortification for West Africa. Similar comparative analysis could therefore guide the development of fortification standards for rice fortification in the West Africa region. The Global Alliance for Improved Nutrition (GAIN) and the Food Fortification Initiative (FFI) in 2016 identified 12 countries, largely in West Africa, with the highest opportunity for their populations to benefit from rice fortification in Africa. Seven of these countries could have their urban populations benefiting more than their rural counterparts. This is largely due to high imports of rice to these countries compared to largely subsistent local production and consumption in rural areas.[13]

> "The data from FAOSTAT indicate that the per capita food supply of milled rice equivalent was highest for West Africa"

TABLE 1: : Rice consumption per person per day (g) and the proportion (%) of industrially milled local rice produced in West African countries [17,18]

Country	Rice consumption per person per day (grams)	Percentage of industrially milled local rice produced
Benin	146	‹20
Cape Verde	134	0 (all imported)
Côte d'Ivoire	175	‹20
The Gambia	169	0
Ghana	88	30
Guinea	266	0
Guinea-Bissau	269	0
Liberia	94.8	1
Mali	156	40
Nigeria	77	40
Senegal	144	40
Sierra Leone	283	7

FIGURE 1: The prevalence of vitamin A deficiency and stunting in children under five, anemia in women of reproductive age, and proportion of calories from non-staples by subregion in sub-Saharan Africa (GNR 2017)[20]

The data from FAOSTAT, when graphically plotted for various subregions of sub-Saharan Africa, indicate that the per capita food supply of milled rice equivalent was highest for West Africa and increased from an estimated 30 kg/capita/year to close to 40 kg/capita/year from 1998 to 2012, while for all other regions of Africa (Southern, Central and Eastern Africa) the increase narrowly moved from about 10 kg/capita/year to about 15 kg/capita/year. A similar trend was observed for the share of kilocalories from rice in the per capita food supply. West Africa registered significantly higher values than the other subregions, at 300 kcal/capita/day in 1998, which rose to nearly 400 kcal/capita/day in 2012. In the other subregions, the per capita daily calorie intake of available rice is estimated to be between 100 and 150 kcal/capita/day over the same time frame (**Table 1**). Rice fortification could therefore be more promising in addressing micronutrient deficiencies in West Africa than in any other subregion of sub-Saharan Africa.[14,15] However, significant barriers to rice fortification in West Africa include "protective national rice self-sufficiency policies and unofficial trade across porous land borders, which counterbalance these opportunities. Moving forward with rice fortification in West Africa will depend on successful navigation of politically sensitive policies, and opportunities to use food distribution programs as part of social protection programs, supported by effective regulatory monitoring."[16]

Consumption of other foods and relative proportions of calories from non-staples

The 2017 Global Nutrition Report estimates that among the four subregions of sub-Saharan Africa, Southern Africa has the highest proportion of calorie consumption from non-staple foods and apparently has the lowest prevalence of micronutrient deficiencies as well as the lowest prevalence of vitamin A deficiency in preschool children and of anemia in women of reproductive age. Southern Africa also has the lowest prevalence of stunting and has been registering higher levels of overweight, obesity and diet-related noncommunicable diseases due to the effects of changing diets and lifestyles, particularly in the growing middle-income class. West Africa relative to Eastern Africa also has lower stunting prevalence. However, all subregions have vitamin A deficiency prevalence above 40% in preschool children, with Central Africa having over 50% prevalence. Anemia in women of reproductive age remains a public health concern, in particular for Eastern, Central and West Africa.[19]

"Rice fortification could be more promising in addressing micronutrient deficiencies in West Africa than in any other subregion of sub-Saharan Africa"

Looking at **Figure 1**, Southern Africa, which has the highest proportion of calorie from non-staples, has the lowest rates of vitamin A deficiency, anemia and stunting. Dietary diversification is therefore key for improving micronutrient and overall nutrition outcomes even where food fortification exists. There is evidence of positive correlation between the level of diversity of food groups in a diet and the increase in the micronutrient profile of that diet. Data from FAOSTAT indicate that the food supply per capita for meat is highest in Southern Africa (40 to 50 kg/capita/year from 1998 to 2012), followed by Central Africa and the rest, which are all below 25 kg/capita/year as of 2012.[21] Eastern and West Africa, however, lead in the consumption of fish and seafood as food supply per capita, with all subregions consuming below 15 kg/capita/year of fish and seafood.[22] Africa also consumes relatively low quantities of pulses and other products – less than 12 kg/capita/year over the past decade.[23] The consumption of fruit excluding wine remains relatively low, with Central Africa leading other subregions at an estimated annual per capita consumption level of around 80 kg. Actual fruit consumption is, however, highest in West Africa and is declining to below 15 kg/capita/year, and is lowest in Central Africa.[24,25] The consumption of vegetables (prepared, in preservatives, dehydrated, canned, fresh or dried) is relatively high in Eastern and West Africa at 45 kg/capita/year and around 38 kg/capita/year respectively in the last decade.[26] West Africa also consumes higher amounts of wheat products compared to other subregions, with an estimated 58 kg/capita/year – almost double those of other subregions which are estimated at below 30 kg/capita/year.[27] In comparison, Southern Africa consumes more maize products, as much as 100 kg/capita/year, followed by Eastern Africa, estimated at around 60 kg/capita/year.[28] Maize flour fortification could therefore have a more significant impact in Southern and Eastern Africa compared to West Africa, where rice remains the predominant cereal consumed by the populace. The annual per capita consumption of vegetable oils, one of the key food vehicles fortified under mandatory regulations in West Africa, remains quite low in all regions, with West and Southern Africa leading at above 10 kg while the other two sub-regions – Central and Eastern Africa – consume below this estimated figure.[29]

Five Fortification Assessment Coverage Toolkit (FACT) surveys have been conducted in West Africa. The results of the FACT surveys varied widely from country to country. Overall, the results showed that improvements are required for each national fortification program to increase coverage and quality. Only Senegal achieved ≥50% coverage for the consumption of fortified wheat flour nationwide, at 51.2%.[30] For edible oil, only Côte d'Ivoire has achieved ≥50% for consumption of fortified oil.[31] In addition, the FACT surveys in Burkina Faso and Ebonyi and Sokoto, Nigeria, revealed that there is scope to expand fortification to new vehicles including rice. In Burkina Faso, the results revealed that rice, tomato paste and bouillon cubes are widely available across all regions of the country, although over 90% of the available brands are imported.

Conclusion and recommendation

Unlike maize and other cereals, rice remains a very important food commodity consumed largely in West Africa with close to 400 kcal per capita per day consumed by the population in the subregion and an annual per capita food supply as milled rice equivalent of 40 kg/capita/year. Rice fortification coupled with nutrition education and other complementary micronutrient interventions could significantly contribute to addressing deficiencies in essential vitamins and minerals in West Africa and other subregions of sub-Saharan Africa. Sound food consumption data and estimates on per capita consumption are essential for planning the addition of micronutrients to fortified food vehicles.

> "Rice is an ideal food vehicle for fortification due to its wide consumption, reach, coverage, acceptability and palatability"

The estimates provided in this article are equivalent available quantities. However, actual levels should be estimated through food frequency surveys for various geographic regions, socioeconomic and demographic groupings within specific contexts prior to embarking on rice fortification programs. Rice is consumed in various forms, with multiple accompaniments, including soups and stews. West Africa has mandatory fortification of wheat flour and vegetable oil across 15 countries. Countries have the capacity to increase local rice production and processing prior to fortification, but currently Mali is the only country that has piloted fortifying rice in West Africa, and is the first in Africa. Rice is an ideal food vehicle for fortification due to its wide consumption, reach, coverage, acceptability and palatability. Rice fortification should therefore be advanced in West Africa with access and availability for consumption by all segments of the population irrespective of geographic, cultural, or socioeconomic situation. The coordinated and integrated implementation of rice fortification along with other food vehicles, as well as complementary nutrition interventions, will significantly contribute to improving nutrition outcomes and help address micronutrient deficiencies in Africa. Governments and policymakers should therefore be assisted in forging public–private partnerships to scale up rice fortification in Africa.

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Food Fortification in West Africa

Progress and lessons learned

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Key Messages

- This paper discusses the roles of key stakeholders and essential processes at the national and regional level that have advanced large-scale food fortification across West Africa, while highlighting important lessons learned that may be applicable to other countries and regions.
- Significant progress has been achieved in food fortification in West Africa over the past 15 years through regional commitment and leadership complemented by national level action.
- While most countries in West Africa have mandatory fortification legislation, fortification is an evolving, dynamic process that requires continuous evidence-informed reassessment of performance, priorities and impact.

Introduction

Fortification in West Africa

Micronutrient deficiencies are key contributors to increased morbidity, reduced productivity and premature death in West Africa.[1] Iron deficiency anemia accounts for 20% of all maternal mortality in West Africa while over 40% of children in the Economic Community of West African States (ECOWAS) region are at risk of vitamin A deficiency.[2] In addition to nutrition education, dietary diversification, micronutrient supplementation and public health measures such as deworming, food fortification has been an important strategy for improving nutritional status in West Africa.

The West African Health Organization (WAHO) and international partners organized a public-private sector dialogue on food fortification in 2002, the same year Nigeria became the first country in the region to mandate fortification of wheat flour, vegetable oil, sugar and maize flour. The West African Economic and Monetary Union (UEMOA) Commission subsequently supported the development of subregional fortification standards, quality assurance and quality control (QA/QC) guidelines and a fortification logo. Capacity-building of industry and regulatory bodies followed, as did mobilization of national fortification alliances, consumer associations and the public. Harmonized regional fortification standards are now in place across the ECOWAS zone.

> "Harmonized regional fortification standards are now in place across the ECOWAS zone"

Regional stakeholders

WAHO

As the official health body of ECOWAS, WAHO has been front and center in advancing food fortification in West Africa since its member ministers of health passed a resolution in support of universal salt iodization in 1994. WAHO co-organized public-private sector dialogues on food fortification in 2002 and 2007 and passed another health ministers' resolution in 2006 for mandatory fortification of vegetable oil and wheat flour. WAHO carries significant political influence on national level health and nutrition policies, and the political leadership it has shown in support of food fortification has translated into national-level action.

UEMOA

Covering the subregional West African Franc zone of eight countries, the UEMOA Commission has contributed nearly US$1 million over the past five years in support of food fortification, rallying countries and industry around fortification, strengthening technical capacity of the public and private sectors, raising consumer awareness and harmonizing standards. UEMOA convenes country fortification focal points, industry and regional industry associations twice yearly to review the status and progress of food fortification in the region.

Regional industry associations

The UEMOA Commission has also worked closely with two regional industry associations: the Professional Millers Association (AIM-UEMOA) and the Professional Oil Producers Association (AIFO-UEMOA), both of which have actively supported food fortification. In fact, AIFO-UEMOA called on its member industries to begin fortifying oil voluntarily in 2006, before any UEMOA country had mandated it.

ECOWAS

The ECOWAS Commission, and its departments of Industry and Private Sector Promotion, Trade, and ECOSHAM, have been instrumental to fortification standards harmonization across all 15 member countries. ECOWAS is now considering bouillon, sugar and maize flour fortification standards, adoption of the ENRICHI fortification logo, regulation for fortified foods subject to harmonized standards, and development of ECOWAS-wide QA/QC fortification guidelines through the West Africa Quality System program.

International organizations

Numerous international agencies have played important roles in food fortification across West Africa, supporting capacity-building, evidence generation, monitoring and surveillance, convening stakeholders, advocacy and equipment procurement. These partners include Helen Keller International (HKI), UNICEF, Nutrition International, the Global Alliance for Improved Nutrition (GAIN), the Food Fortification Initiative (FFI), the International Federation for Spina Bifida and Hydrocephalus and Smarter Futures consortium, Project Healthy Children, and the International Micronutrient Malnutrition Prevention and Control (IMMPaCt) program of the United States Centers for Disease Control and Prevention.

Regional efforts in support of food fortification

Harmonized regional fortification standards

In 2009, the UEMOA Commission developed standards for fortified vegetable oil and wheat flour, aligned with WHO recommendations,[3,4] which were then mandated by all eight member countries. Building on UEMOA's success, a workshop was organized in late 2013 to reach consensus on and plan the process for harmonizing standards for fortified wheat flour, vegetable oil and iodized salt across the entire 15-member ECOWAS community through the ECOWAS Harmonization Model (ECOSHAM), the framework for aligning commodity standards in the region.

In 2014, vegetable oil, wheat flour and salt were formally introduced into the ECOSHAM process. During numerous technical meetings, current fortification standards for these commodities were reviewed and initial harmonized standards developed. Following public review in each country, the standards were revised and a formal ECOWAS standard developed and submitted to the Regional Technical Harmonization Committee on Food Products for endorsement by all 15 member-country representatives. These standards were then adopted by the ECOWAS Ministers of Industry before final endorsement by the Council of Ministers for African Integration. Following this two-year process, countries are now obliged to modify their legal frameworks (laws, decrees, etc.) to incorporate the new standard.

Regional fortification logo

In order to raise awareness and facilitate identification of fortified foods, UEMOA developed the ENRICHI fortification logo (**Figure 1**). The logo is a registered trademark with the African Intellectual Property Organization, and UEMOA developed guidelines on use and control of the ENRICHI logo. Wheat millers and oil producers in all eight UEMOA countries utilize the logo, which has also been adopted by three non-UEMOA countries: Cape Verde, Guinea, and Liberia. In another example of sub-regional (UEMOA) fortification initiatives resulting in regional (ECOWAS) uptake, ECOSHAM is now considering adoption of the logo for the entire ECOWAS region.

FIGURE 1: ENRICHI fortification logo

Regional QA/QC guidelines

The UEMOA Commission also developed regional guidelines on wheat flour, salt and vegetable oil fortification to promote consistent and quality production of fortified staples. Draft guidelines were developed by the Commission and then extensively reviewed by national-level technical committees. The guidelines cover fortification operational processes; micronutrient premix procurement, storage and handling; quality control, sampling and analysis; record-keeping; labeling with the EN-

TABLE 1: National-level regulatory status on food fortification in ECOWAS member states

ECOWAS countries	Status of fortification regulation (year mandated)			
(UEMOA italicized)	Vegetable oil	Wheat flour	Sugar	Maize flour
Benin	**Mandatory (2012)**	**Mandatory (2012)**		
Burkina Faso	**Mandatory (2012)**	**Mandatory (2012)**		
Côte d'Ivoire	**Mandatory (2007)**	**Mandatory (2007)**		
Cape Verde	Voluntary	**Mandatory (2014)**		
The Gambia	Voluntary	Voluntary		
Ghana	**Mandatory (2006)**	**Mandatory (2006)**		
Guinea-Bissau	**Mandatory (2014)**	**Mandatory (2014)**		
Guinea	**Mandatory (2012)**	**Mandatory (2005)**		
Liberia	**Mandatory (2014)**	**Mandatory (2014)**	**Mandatory (2014)**	
Mali	**Mandatory (2017)**	**Mandatory (2011)**		
Niger	**Mandatory (2012)**	**Mandatory (2012)**		
Nigeria	**Mandatory (2002)**	**Mandatory (2002)**	**Mandatory (2002)**	**Mandatory (2002)**
Senegal	**Mandatory (2009)**	**Mandatory (2009)**		
Sierra Leone	**Mandatory (2011)**	**Mandatory (2011)**		
Togo	**Mandatory (2012)**	**Mandatory (2012)**		

RICHI logo; and packaging and distribution of fortified oil and flour and iodized salt.

QA/QC capacity-building of the public and private sectors

Utilizing the regional QA/QC guidelines, the UEMOA Commission and partners have organized numerous national- and regional-level workshops for the private and public sectors on QA/QC and Good Manufacturing Practices in wheat flour and vegetable oil fortification. Recognizing that quality is everyone's responsibility, participants have included representatives from food control agencies, regulatory and standard-setting bodies, customs departments, consumer associations, industry and importers.

National stakeholders

Government

At the country level, many sectors and agencies within the government are critical to fortification. Often, the ministry of health is the first involved, as fortification is considered a nutrition intervention. Ministries of trade, industry, finance and agriculture are subsequently engaged, while standard-setting bodies, regulatory agencies, customs departments and reference laboratories also play critical roles.

Industry

Without industry, there would be no fortification. Industry is, therefore, engaged from the beginning to ensure buy-in, boost capacity, and engender understanding, ownership and compliance. Moreover, standards, compliance requirements and regulations must be feasible, further necessitating active engagement with industry. In addition to millers and oil producers, importers, premix suppliers and analytical equipment suppliers have been engaged.

Fortification alliances

Multisector food fortification alliances are functional in most countries in the region and serve as platforms to review and prioritize food fortification activities, ensuring that fortification remains on the national agenda. Alliances have contributed to the development of fortification strategic plans, updating of legal frameworks in alignment with UEMOA and ECOWAS standards, and monitoring of program progress and performance.

Consumer associations and civil society

For fortification to be successful, there must be public demand and support for the process. Even mandatory fortification can fail if there is widespread misunderstanding of it, or resistance to it, by industry, the public, or civil society. Consumer associations and civil-society organizations thus play critical roles in raising awareness, advocating for improvements and monitoring performance. Civil society organizations can also promote demand for fortified foods through their nutrition-based social and behavior-change communication activities.

National-level efforts in support of food fortification

FRAT surveys

As one of the first steps of food fortification, many countries in the region conducted Fortification Rapid Assessment Tool (FRAT) surveys to identify food fortification vehicles. These nationally representative, cross-sectional cluster surveys assessed consumption patterns of children and women of reproductive

TABLE 2: Examples of standards in the ECOWAS region

Country |	Wheat flour			Vegetable oil	Sugar	Maize flour
region	Iron	Folic acid	Additional	Vitamin A	Vitamin A	
	(ppm / form)	(ppm)	(ppm | form)	(ppm)	(ppm | form)	(ppm | form)
UEMOA	60 (FF, FS, EL)	2.5		11–24		
ECOWAS	60 (FF/FS) 40 (EDTA)	2.6		11–24	7.5 (Retinyl palmitate)	
Ghana	58.5 (FF)	2.08	Vit. A (2.0); Zinc (28.3); B_{12} (0.01); Thiamine (8.4); Niacin (59); Riboflavin (4.5)	10.0		
Nigeria	40 (NaFeEDTA)	2.6	Vit. A (2.0); Zinc (50); B_{12}(0.02); Thiamine (6); Niacin (45); Riboflavin (6)	20,000 (IU/kg)	25,000 IU/kg (Retinyl palmitate)	Vit. A (2.0); NaFeEDTA (40); Folic acid (2.6); Zinc (50); B_{12} (0.02); Thiamine (6); Niacin (45); Riboflavin (6)
Liberia	60 (FF); 40 (NaFeEDTA)	2.6	B_{12} (0.04); Zinc (95); Thiamine (8.5); Niacin (59); Riboflavin (5)	20 (Retinyl palmitate)	15 (Retinyl palmitate)	

age through 24-hour recall and weekly food frequency, with the goal of identifying major potential food vehicles to deliver vitamin A, iron, B-complex vitamins and zinc. In Senegal, for example, wheat flour, vegetable oil, sugar, bouillon and tomato paste were all assessed. Across West Africa, wheat flour and vegetable oil were prioritized for fortification since they were consumed by large proportions of the population at consistent daily amounts and were free of negative perceptions. Fortification was also determined to be feasible technically and affordable to industry and consumers. Political will existed within governments and the private sector. Importantly, feasibility was reflected in the structure of the flour and oil industries: centralized, large-scale producers covered the vast majority of population needs.

Mandatory fortification legislation

Parallel with or subsequent to the development of regional fortification standards by UEMOA, country governments began legally mandating wheat flour fortification with iron and folic acid and vegetable oil fortification with vitamin A. Some countries also permitted wheat flour fortification with zinc (Benin, Guinea, Liberia, and Sierra Leone) or vitamin A (Ghana and Nigeria). Nigeria and Liberia also mandate fortification of sugar and Nigeria additionally mandates maize flour. Both regional bodies and international organizations supported national standards bodies, food control agencies and ministries of health and trade to develop the fortification standards (or adopt regional standards) and enact the necessary legal framework (decrees or laws). As **Table 1** shows, 14 of the 15 ECOWAS countries now have mandatory wheat flour fortification, and 13 of 15 mandate oil fortification. For those countries without mandatory fortification, fortification may be voluntarily practiced, but must follow the regional standards.

Industry capacity-building

In addition to developing fortification legislation and standards, significant capacity-building of fortifying industries was conducted to improve fortification processes, strengthen QA/QC and food safety practices, and ensure understanding of fortification requirements. Industry capacity and technological assessments were conducted to identify and then address plant, equipment and training needs, including procurement of fortification equipment and premix; aggregation of premix orders to ensure economies of scale and purchase of quality, accredited inputs; installation and testing of equipment; and QA/QC sampling and testing. Plant staff were trained in fortification processes, equipment maintenance, QA/QC, food safety, Good Manufacturing Practices and Hazard Analysis and Critical Control Points. Public- and private-sector representatives were often invited to joint trainings to ensure common understanding of each other's roles and responsibilities, thereby promoting cohesion among stakeholders.

Government capacity-building

In addition to building industry capacity, training of food control and regulatory agencies was organized to reinforce external quality control, regulatory monitoring and compliance enforcement. At both national and regional trainings, standards body, food control, reference laboratory, and customs staff were trained on national-level and UEMOA standards for wheat flour and vegetable oil fortification, quantitative and qualitative analytical techniques and tools/equipment for monitoring micronutrient levels in fortified foods, inspection and control procedures at borders and ports, and compliance enforcement.

Communications and awareness-raising among importers, consumers, and the media

Sensitization workshops were organized across the region to improve importer awareness of country and regional fortification requirements. Consumer associations and journalists were also sensitized to expand communication channels with the public on the importance and recognition of fortified foods. The journalists subsequently published articles in print media and aired radio and television spots on fortification.

National communications campaigns promoting awareness and consumption of fortified foods and recognition of the ENRICHI logo were organized by many countries in the region. The goal was primarily to engender support for food fortification and communicate the importance of micronutrients for nutrition and health. In Burkina Faso, for example, the national fortification alliance and several consumer associations organized television and radio broadcasts in French and local languages. In Senegal, mass media and social marketing tools were developed to promote consumption of fortified foods and 13 consumer associations and civil society organizations sensitized on use of the tool. Africable cable news channel organized a caravan that traveled to multiple countries across West Africa engaging consumers in major cities while conducting live broadcasts on food fortification and the ENRICHI logo.

Monitoring

External quality control by regulatory bodies is essential to enforce compliance, as is control of imported foods through inspection agencies which have been equipped with and trained in the use of qualitative and quantitative testing methods to ensure conformity with standards. The UEMOA QA/QC guidelines cover procedures for inspection and control, serving in some countries as the basis for compliance enforcement and reporting. Results of monitoring are reported through some national fortification alliances, but not in all countries.

Since 2014, Fortification Assessment Coverage Toolkit (FACT) surveys have been conducted in four countries (Senegal, Côte d'Ivoire, Burkina Faso, and Nigeria) at the national or subnational level to measure the current effective coverage of fortified foods on the market, as well as to explore the potential of other industry-manufactured foods for fortification based on market penetration, industry/trade production patterns and consumption patterns. The results varied widely across countries but demonstrated an important ongoing need for improvements in fortification coverage and quality.[5]

Lessons learned from fortification in West Africa

A continuously evidence-based and evidence-informed system

Evidence is essential to inform the design of, demonstrate the need for, and measure performance and impact of food fortification. UEMOA and ECOWAS fortification standards (**Table 2**) align with WHO food fortification (2006)[6] and wheat flour and maize flour fortification (2009)[3] guidelines, which provide evidence-informed recommendations on setting beneficial and safe standards.[7]

Micronutrient deficiency prevalence and food consumption data have informed food fortification vehicle and micronutrient selection as well as fortification levels. Industry and regulatory body capacity assessments across the region were used to identify equipment and human resource gaps. Ongoing regulatory monitoring has been critical to quality and performance measurement, while coverage surveying demonstrates scale and facilitates decisions on vehicle and micronutrient selection. Additionally, there are increasing experience and opportunities with integration of fortification data into micronutrient surveillance platforms and health management information systems to further inform food fortification priorities and communicate fortification performance.

The virtues of patience and practicality

Given the number of stakeholders, across multiple sectors in widely different country contexts, with different priorities and paces of action, it is necessary to be patient and practical when launching and scaling up food fortification. Wheat flour and vegetable oil were prioritized, in part, because these industries tend to be centralized and large-scale, making monitoring of performance and quality more feasible and significant scale and population coverage more attainable.

Moreover, fortification relies on both the private sector to produce high-quality fortified foods under safe and hygienic conditions and the government to ensure a fair business environment by enforcing national regulations among all producers.[8] Small-scale producers do not always have the available capital to purchase premix or invest in fortification equipment, and monitoring food safety among thousands or tens of thousands of small units – as is the case with salt iodization and maize fortification – becomes especially challenging, particularly when fortification is being initiated.

Regional political will complemented by national-level action

Regional bodies catalyzed a supportive environment for fortification in West Africa, prompting country-level action. The political will and commitment of regional health and economic bodies and regional industry associations have been critical to launching food fortification across West Africa. Through the leadership shown by these bodies, national governments abided by resolutions and recommendations to initiate and mandate food fortification.

Important as the regional leadership has been, it is not a substitute for country-level action. Multiple ministries have coordinated efforts to fund, implement, and monitor food fortification. Fortification alliances have convened multiple sectors, and industries have accepted the risk of changing their food products and production practices. Without cooperation and coordination at the national level, fortification would not have progressed as far as it has.

Clear roles and responsibilities

Clarified roles and responsibilities and coordinated efforts in enforcing compliance with standards is needed at the national level. Many agencies are involved in quality control management, inspection, compliance and control. These include food safety, customs, standard-setting bodies, food and drug control, and the industry itself. However, roles and responsibilities among the numerous agencies are not clear in all countries, nor is there always a single authority responsible for overall management. This is needed at the country level and is especially important once fortification has been launched and the intensity of the broad partner engagement wanes. The UEMOA and ECOWAS Commissions have both voiced their support for this.

Legislation is only the beginning

There is the risk that once fortification is legislated, donors, partners and governments may consider the work to be complete. However, fortification is a dynamic process that requires continuous monitoring and reassessment to ensure that it continually meets population needs. It is important to measure coverage and consumption to verify that there is not only enough fortified food for the population but that the food is also reaching and being consumed by the population.

Over time, countries must eventually assess the added value and feasibility of other potential fortification vehicles, micronutrients and technologies. While initial efforts have focused on wheat flour and vegetable oil, many countries assessed rice, bouillon, sugar and maize flour consumption in FRAT and FACT surveys and voluntary fortification of these commodities already exists in some countries (and is mandated in others). Countries with more mature fortification programs (7–10 years) are starting to reassess whether current vehicles, with current micronutrients at current levels, utilizing current technologies, are meeting the needs of their population, given changes in consumption patterns, micronutrient deficiency prevalence rates and dietary and demographic transitions. This requires ongoing, data-informed, multisectoral engagement of fortification stakeholders, and speaks to the importance of fortification alliances as platforms and of fortification and nutrition information systems as data sources to inform decisions.

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Feasibility and Potential for Rice Fortification in Africa

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Key Messages

- The fortification of rice in Africa offers a significant opportunity to improve intakes of essential vitamins and minerals among at least 146 million people, spread across 12 countries, who are considered potential beneficiaries of the intervention.
- Domestic milling capacity to implement rice fortification is not yet feasible in any of the countries studied. Imported rice remains the dominant opportunity for feasible rice fortification.
- Efforts on a single country-by-country basis will not lead to sufficient demand for fortified rice to justify private-sector investment in fortified kernel production. Rice fortification at scale will require a regional effort for mandatory rice fortification and/or a significant leverage of publicly funded food programs (e.g., food distribution, school meals).
- Sustainable rice fortification will depend on the successful navigation of politically sensitive rice policies, opportunities to use food distribution programs, and effective regulatory monitoring.
- Several countries considering opportunities for rice fortification already have mandatory fortification of other foods – e.g., wheat flour, oil, salt. For those countries it would be beneficial to evaluate the compliance, coverage, and nutrition contribution from existing fortified foods.

Background

Why rice in Africa?

Outside of Asia, the largest per capita rice consumption is in Africa, where 19 countries have more than 75 grams per capita per day (g/c/d) of rice available on average for human consumption (**Table 1**).[1] The World Health Organization considers prevalence of anemia exceeding 40% in a population as being of "severe" public health significance.[2] For every single one of these countries, anemia is categorized as "severe" for children under 5; in 12 out of these 19 countries anemia is of "severe" public health significance for non-pregnant women. For further information about vitamin and mineral deficiencies in the region, see article Overview of Evidence and Recommendations for Effective Large-scale Rice Fortification on page 55. This suggests that rice fortification in Africa is a potential opportunity to improve vitamin and mineral intakes across the population, as well as to rapidly increase the volumes of rice fortified globally.

Large stocks of rice held in port warehouses by private importers are a key aspect of food security in Liberia and other countries of West Africa

TABLE 1: African countries with over 75 g/c/d of rice available (FAO 2013)

WEST AFRICA	OUTSIDE OF WEST AFRICA
Benin	Comoros[a]
Cape Verde	Djibouti
Côte d'Ivoire	Egypt
The Gambia	Gabon
Ghana	Madagascar
Guinea	Mauritius
Guinea-Bissau	
Liberia	
Mali	
Mauritania	
Nigeria	
São Tomé and Príncipe[b]	
Sierra Leone	

[a] FAO's Food Balance Sheets do not have data for Comoros; however, field interviews in Comoros suggest rice availability in Comoros meets this criterion.

[b] At time of work, only FAO 2011 food availability was available; at that time, rice availability for Sao Tome and Principe was under 75 g/c/d and the country was not included in the original report. The data presented here have been updated to include 2013 FAO data, but a country profile for São Tomé and Príncipe was not added as its population and total rice volume would not significantly impact the results of the analysis.

However, national-level availability and consumption alone do not describe the entire picture. To ensure feasibility and describe potential for impact, we need to understand consumption patterns among specific populations (e.g., women of reproductive age, rural populations) and the overlap with other fortified/fortifiable food vehicles (e.g., maize and wheat flour). A third consideration is the rice supply chain for both imports and domestic production; that is the focus of this assessment. The Food Fortification Initiative (FFI) and the Global Alliance for Improved Nutrition (GAIN) used primary and secondary data to identify opportunities to use rice fortification in Africa as a way to improve nutrition and to identify priorities for establishing the intervention in Africa.

Rice fortification at scale

Fortifying rice requires a different process than fortifying flour. Rice is commonly eaten in its milled grain form rather than as flour and rice fortification requires creating a fortified kernel. Consequently, the cost of fortifying rice is reportedly seven times the cost of fortifying flour.[3] For basics on rice fortification technology, see Peiman Milani's article on page 48.

Another economic factor is that rice fortification is not yet practiced on a global scale. For an overview of current rice fortification status worldwide, see Becky L. Tsang's article on page 68. Today, fortified kernel manufacturers run at low utilization to supply fortified kernels for small volumes of rice used in pilot projects and targeted food distribution programs. Fortifying the estimated 23.8 million metric tons of rice available for food in African countries[4] could increase global production of fortified kernels, improve the industry's economies of scale and catalyze lower prices for fortified rice. But how much of that 23.8 million metric tons is a feasible fortification opportunity, and of that quantity, who would benefit?

Opportunities for rice fortification in Africa

Methods

Using a combination of field interviews and desk reviews, we assessed the rice supply chain in 19 African countries. Secondary data sources included United Nations Comtrade for bilateral rice trade data; both the Food and Agriculture Organization and the United States Department of Agriculture for rice availability and import (as aggregated by IndexMundi), production, and consumption in each country; USDA Foreign Agricultural Service Feed Grains Yearbooks: the USAID 2009 West Africa Value Chain Analysis; and The World Factbook for population and urbanization estimates and trends.

Results

An overview of the rice market and industry for West African countries is given in the Country Profiles section at the end of this article.

Preferences for rice types and quality

Fortified kernels (coated or extruded) can be produced to match most rice shapes and sizes; understanding rice prefer-

Broken rice is preferred in many West African countries for its affordability and texture in local dishes

TABLE 2: Rice, wheat flour and maize flour availability and % industrially milled by country (data in bold indicate mandatory fortification of the relevant cereal grain, FAO 2013)[10]

	Rice			Wheat flour		Maize flour	
	g/c/d	% industrially milled	% imported	g/c/d	% industrially milled	g/c/d	% industrially milled
WEST AFRICA							
Benin	146	20%	66%	36	**100%**	110	Unknown
Cape Verde	134	0%	123%	106	**100%**	102	Unknown
Côte d'Ivoire	174	8%	58%	57	**98%**	60	Unknown
The Gambia	169	0%	56%	104	100%	48	Unknown
Ghana	88	11%–23%	62%	40	**100%**	70	Unknown
Guinea	266	0%	13%	51	**100%**	26	Unknown
Guinea-Bissau	269	0%	41%	31	100%	28	Unknown
Liberia	260	<6%	33%	30	**100%**	0	Unknown
Mali	156	<6%	12%	34	**100%**	97	Unknown
Mauritania	133	Unknown	83%	276	**95%**	10	Unknown
Nigeria	77	12%–24%	40%	57	**100%**	90	**Unknown**
Senegal	198	38%–44%	105%	102	**100%**	51	Unknown
Sierra Leone	283	<7%	31%	24	**100%**	14	Unknown
OUTSIDE OF WEST AFRICA							
Comoros	281	0%	100%	Unknown	100%	Unknown	Unknown
Djibouti	122	0%	129%	326	**100%**	3	Unknown
Egypt	108	100%	3%	402	**100%**	173	Unknown
Gabon	94	0%	106%	172	100%	45	Unknown
Madagascar	281	1%	16%	25	100%	49	Unknown
Mauritius	142	Unknown	84%	312	95%	8	Unknown

g/c/d: grams per capita per day.

ences in a population is key to ensuring fortified rice is accepted by consumers. **Table 3** details market preferences for rice by country.

Generally, the more price-sensitive the consumer, the greater the market for rice with a high percentage of broken kernels. In The Gambia, Guinea-Bissau, Liberia, Mauritania, Senegal and Sierra Leone, the preference is for 100% broken rice, likely due to both low price and common use in traditional dishes. Although parboiled rice is consumed by subpopulations in most countries, Nigeria is the only country that exclusively prefers parboiled rice. Both broken kernels and parboiled rice can be fortified.

Opportunities for fortifying domestically grown rice

Fifteen of the 19 countries produce rice domestically. The feasibility of fortifying domestic rice depends on the structure of the local milling industry. Rice fortification at small mills (defined at less than five metric tons per hour)[5] is cost-prohibitive compared to fortification at large mills. Larger mills can take advantage of economies of scale and are more likely to have greater resources to implement fortification. Enforcing fortification by government agencies is also difficult due to the high numbers of small mills in existence.[6]

Of the countries reviewed, only Egypt has a large domestic rice-milling capacity. Nearly all the domestic rice produced in Egypt is milled industrially due to the country's role as a key regional rice exporter (**Table 2**). Hand-pounding of rice in remote areas or toll milling in village mills is still overwhelmingly the practice for domestic rice grown in other countries assessed. Estimating the total volume of domestically grown rice that is industrially milled suggests that only 860,000 metric tons of rice could be fortified across 12 countries identified as opportunities for rice fortification (**Table 4**).

> "Africa's large volume of rice imports is a great opportunity"

Opportunities for fortifying imported rice

On the other hand, Africa's large volume of rice imports is a great opportunity. Fortifying the 5.7 million metric tons of rice

TABLE 3: Market preferences for rice varieties and quality, by country[11]

WEST AFRICA	
Benin	› Primarily an importer of high-quality white rice, brokens ranging from 5% to 25%.
	› High-quality white and aromatic rice is preferred in urban areas.
	› Some consumers also prefer parboiled rice, especially in rural areas.
	› Imported parboiled rice likely re-exported to Nigeria.
Cape Verde	› Market preference for medium-grain white rice from Thailand, proportion of brokens unknown. No rice grown in Cape Verde.
Côte d'Ivoire	› The overall market is dominated by 15% broken white rice, followed by 50% brokens.
	High-quality 5% aromatic rice is considered only 2% of the market.
	› About half of rice imports are aromatic, from Thailand and Vietnam.
	› Local rice is mostly consumed in rural areas.
	› Limited local parboiling near the border with Guinea.
The Gambia	› Price-conscious market; consumer preference is for 100% broken rice.
	› Some 25% broken white rice is imported as well.
	› Local rice is considered premium and is more expensive than imported.
Ghana	› Rice is not an essential staple food. Consumer preference is for high-quality white and aromatic rice (5% brokens).
	Aromatic rice is considered 80% of the market and sold at a premium, and Ghana is Africa's largest importer of aromatic rice.
	› There is ~10% demand for 100% broken rice used specifically for traditional dishes.
	› Rural households parboil rice, particularly in the north.
	› Imported parboiled rice serves the Muslim population, ~1% of the market.
Guinea	› Imports are at least 50% low-quality 100% broken rice, but parboiled and 25% broken rice is also consumed
	in the urban market.
	› Rural consumers prefer locally parboiled rice.
	› Some varieties of local rice are popular and sold at a premium over imported rice.
Guinea-Bissau	› Market preference for 100% broken rice.
Liberia	› Domestic rice parboiled at household or village level.
	› Market dominated by 100% brokens and 50% brokens, with some 5% broken demand from middle-high income consumers.
	› Past reports[12] of 80% preference for round-grain Chinese rice and low-quality parboiled rice.
Mali	› Primarily domestic rice consumed; local rice is ~40% broken due to poor milling.
	› Premium varieties of local rice (e.g., Gambiaka) more expensive than imported rice.
	› Imports include 100% brokens as well as high-quality aromatic rice.
Mauritania	› Consumer preference is for 100% broken rice, both aromatic and white.
Nigeria	› In northern Nigeria the preference is for rice flour (97% share) as opposed to grain. In the south the preference is
	for high-quality parboiled, mostly imported, rice.
Senegal	› Consumer preference is for 100% broken rice, both white and aromatic, but there is approximately a 30% market
	for rice with 50% or less brokens.
	› In rice production areas, local rice is preferred. In urban areas, consumers prefer imported rice; aromatic 100% broken rice
	is preferred in Dakar.
Sierra Leone	› Price-conscious market; importers report that 75% of market is now 100% brokens.
OUTSIDE OF WEST AFRICA	
Comoros	› Rice imported by government agency (Onicor), so availability and price of government-to-government bids may overrule
	market preference for rice. Current contract is for Pakistani rice with 15% brokens but past reports of Vietnamese rice.
	› Higher-income households purchase Pakistani basmati rice.
Djibouti	› White milled rice and red Belem rice; unknown broken percentage.
Egypt	› Domestically grown rice is medium-grain Japonica varieties.
Gabon	› White milled rice, unknown broken percentage or varieties.
Madagascar	› Domestic rice is the main share of national consumption. Several varieties of rice unique to Madagascar are grown.
	› Imported rice is white milled rice from India and Pakistan.
Mauritius	› Primary market is for white milled rice, with a smaller demand for brokens (~22%).

Imported rice is moved around the region through sometimes informal mechanisms. If fortified rice is mandated, regulatory monitoring at land borders will need to be considered.

exported annually to 12 countries in Africa, primarily in West Africa, would immediately bring rice fortification to scale globally (**Table 5**).

Fortifying imported rice is the only rice fortification option in Senegal, Cape Verde, Comoros, Djibouti, and Gabon, where close to 100% of the rice supply is imported. On the other hand, fortifying imported rice is unlikely to be a great opportunity where imported rice is not a significant source of the rice supply (less than 25%) – e.g., Mali, Egypt, and Madagascar (**Table 2**).

Estimating potential population coverage

Understanding the coverage of a fortified food identifies which populations are most likely to benefit. In **Table 4,** the countries shaded green are where fortified rice could be expected to provide a public health impact in certain populations. However, green does not guarantee easy implementation. Issues that could compromise rice fortification are discussed below.

In countries where nearly 100% of rice is imported, it is assumed that the entire population could benefit from rice fortification.[7] This may be an overestimation if rice consumption is not distributed evenly across the population. In nine countries, fortified rice imports are expected to primarily reach the urban populations that consume imported over domestically grown rice. Collectively, the reach of these opportunity countries (highlighted green) is 146 million people (**Table 4**).

Imported rice sources

In 2014–2015, 80 countries exported rice to the 12 African countries considered opportunities. India and Thailand tied as the major sources of imported rice at 2.1 million metric tons of rice. **Table 5** shows the rice origins for each country exporting at least 11,000 metric tons to African countries.

Options for points of fortification

Rice imported to Africa can be fortified in two locations:

1. Country of rice origin
2. Destination (i.e., after arrival into a country)

Each option has advantages and disadvantages. This analysis suggests that fortification at country of origin is better suited for West African imports.

> "This analysis suggests that fortification at country of origin is better suited for West African imports"

Fortifying rice in countries of origin would result in private-sector investment in high-quality fortified kernel production, thus bringing costs down exponentially. Of Africa's rice imports,

TABLE 4: Population coverage of potential rice fortification opportunities

	Population	% Urban	Population coverage	
			Imported	Domestic
WEST AFRICA				
Benin	10,320,000	44	4,540,800	138,488
Cape Verde	490,000	66	490,000	–
Côte d'Ivoire	20,320,000	54	11,013,440	–
The Gambia	1,840,000	60	1,104,000	397,702
Ghana	25,900,000	54	13,986,000	2,255,902
Guinea	11,750,000	37	–	–
Guinea-Bissau	1,700,000	49	838,100	–
Liberia	4,290,000	50	2,132,130	–
Mali	15,300,000	40	–	–
Mauritania	3,890,000	60	–	–
Nigeria	173,600,000	48	86,800,000	5,636,008
Senegal	14,130,000	44	6,174,810	8,217,475
Sierra Leone	6,090,000	40	–	–
OUTSIDE OF WEST AFRICA				
Comoros	735,000	28	735,000	–
Djibouti	872,000	77	872,000	–
Egypt	82,060,000	43	–	–
Gabon	1,672,000	87	1,457,984	–
Madagascar	22,920,000	35	–	–
Mauritius	1,296,000	40	–	–
TOTAL POPULATION	399,175,000	Coverage	130,144,264	16,645,574

Green: Considered opportunities for rice fortification

Violet: Unknown, and further information necessary

Orange: Unlikely that large volumes of rice could be fortified to benefit a broad segment of the population

the great majority is handled by a few multinational traders, which will facilitate implementation and enforcement of adequately fortified rice.

On the other hand, fortifying rice after importation (using imported or domestically produced kernels) could be very costly. Rice is imported via several modes of transportation, from bulk shipments to bags in containers and bulk holds. Where rice is imported already bagged for retail, blending after importation and repackaging could be cost-prohibitive. Another disadvantage is that domestic blending of fortified rice will require greater regulatory resources from local government compared to monitoring imported rice at a centralized location such as the port.

	Justification
	Fortification of imported rice potentially feasible; could reach the urban population (44% of population).
	Fortification of imported rice is potentially feasible; because no rice is grown or milled domestically and rice is the primary staple grain; fortification would reach the entire population.
	Fortification of imported rice is potentially feasible and would reach the urban population (44% of population).
	Fortification of imported rice is potentially feasible and would reach the urban population (60% of population).
	Fortification of imported rice is potentially feasible and would reach the urban population (54% of population). There may be limited coverage in rural areas that consume imported rice.
	No. Only 37% of the population is urbanized, and this population also consumes both imported and domestically grown rice. Domestic rice is hand pounded and accounts for the majority of rice consumption.
	Fortification of imported rice is potentially feasible and would reach the urban population (49% of population). Rice imports are closely tied to the cashew export industry on a barter basis which may complicate the costs of fortification. Some coverage in rural areas that consume imported rice.
	Fortification of imported rice is potentially feasible and would reach the urban population (50% of population).
	No. Only 40% of the population is urbanized and this population also consumes both imported and domestically grown rice. Domestic rice is small milled and accounts for the majority of consumption.
	Domestic milling information required for a conclusion, but expected low impact of rice fortification. Imported rice and domestically produced rice are approximately equal shares and wheat flour is the primary staple.
	Success of rice fortification is highly dependent on the ability to regulate cross-border trade. If all imports were fortified (including illegal imports), fortified rice could reach the urban population (48% of population). Domestic rice milling capacity is growing but 30% of rice at most is industrially milled.
	Fortification of imported rice is potentially feasible and would reach the urban population (44% of population). There may be limited coverage in rural areas that consume imported rice. Fortification of domestic rice production could be possible in the short-term future, as the milling industry is growing quickly.
	No. Small imported rice quantities. Domestic rice is small-milled and accounts for the majority of consumption.
	Fortification of imported rice is potentially feasible. Because almost no rice is grown or milled domestically and rice is the primary staple grain, fortification would reach the entire population.
	Fortification of imported rice is potentially feasible since no rice is grown domestically. However, wheat flour is the primary staple.
	Additional information necessary for a conclusion. Rice fortification depends on the domestic rice-milling industry, which reportedly accounts for 100% of industrial milling; imported rice is a small proportion of rice consumed. Wheat flour is the primary staple.
	Fortification of imported rice is potentially feasible and would reach the urban population (87% of population).
	No. Only 35% of the population is urbanized, and this population also consumes both imported and domestically grown rice. Domestic rice is small-milled and accounts for the majority of consumption.
	Additional information necessary for a conclusion. Rice is primarily imported and may be an opportunity but wheat flour is the primary staple.
	Total potential population coverage through fortified rice: **146,789,838**

Barriers to rice fortification

The opportunities for rice fortification are accompanied by important implementation barriers that must be addressed prior to considering a mandatory rice fortification policy.

Regulatory monitoring at porous land borders and seaports

Rice is an essential commodity for food security and stability, and African rice policies are constantly in flux: duties are raised or lowered depending on global rice prices or expected shortages in the domestic rice crop. These policies result in opportunistic rice trade that can quickly change with the rice policy.

For example, an estimated 70% of the rice imported into Benin's Port of Cotonou in 2014 was illegally destined for Nigeria, due to more favorable rice import duties in Benin. Fortification of rice in Nigeria directly impacts Benin and vice versa. Coordinated efforts are required to ensure that all imports are properly fortified regardless of their final destination.

All countries planning to introduce imported rice fortification, particularly in Africa, have to take regulatory monitoring

TABLE 5: Bilateral rice imports to opportunity countries, by rice import origin, metric tons (2014/2015)[1,13]

COUNTRY	India	Thailand	Pakistan	Vietnam	Brazil
Benin	589,558	614,914	17,718	26,908	13,860
Cape Verde	20	18,361	24	1,820	6,816
Comoros	0	0	80,000	0	0
Côte d'Ivoire	207,531	356,776	65,697	225,525	0
Djibouti	148,575	285	31,255	0	0
Gabon	383	68,408	0	0	0
The Gambia	38,374	31,390	27,611	0	22,796
Ghana	62,063	126,630	8,351	334,555	–
Guinea-Bissau	4,595	11,625	37,785	0	375
Liberia	260,368	1,622	337	0	0
Nigeria	127,210	644,131	27	0	11,072
Senegal	685,482	240,113	11,174	545	50,082
TOTAL	2,124,158	2,114,255	279,978	589,352	105,002

at points of entry seriously. Sources in Madagascar estimate that as much as 30% of rice imports records are falsified to take advantage of the 0% duty on rice imports.[8] Without strong regulatory monitoring of sea and land borders, mandatory rice fortification in one country could lead to smuggling of cheaper, non-fortified rice from a neighboring country.

Government interventions: rice self-sufficiency policies and price interventions

After the 2008 global rice crisis,[9] several countries in Africa (particularly Senegal, Benin, Mali, Côte d'Ivoire, Nigeria and Sierra Leone) created national rice self-sufficiency and price intervention policies intended to reduce the national dependence on imported rice. Mandatory fortification of imported rice may seem to be a direct contrast to self-sufficiency priorities. Instead, policies should consider how rice fortification will apply to both the imported and domestic rice industries. Rice fortification can be phased into domestic rice milling as the industry modernizes.

> "Regional action will have the greatest likelihood of bringing fortified rice to the tables of 146 million people living in Africa"

Conclusion

Regional activity required for scale

Rice fortification in one or two countries in Africa will likely not significantly change the economics of rice fortification. For impactful rice fortification at scale and to address the porous borders in this region, regional action will have the greatest likelihood of bringing fortified rice to the tables of 146 million people living in Africa. At the same time, rice fortification does not exist in a vacuum. In opportunity countries, evaluating the compliance, coverage and nutrient contribution from existing mandatory fortification efforts of other staple foods (e.g., wheat flour, oil and salt) would be beneficial to understand the potential implications of rice fortification.

To create sufficient demand for fortified rice in Africa, a collective strategy is necessary – individual country action will fail to achieve the scale necessary for rice fortification to succeed as a public health intervention.

References & notes on the text

1. FAO. FAOSTAT. 2013 Food Balance Sheets. Internet: http://faostat3.fao.org/ (accessed June 6, 2018).
2. WHO. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Vitamin and Mineral Nutrition Information System. Geneva, World Health Organization, 2011 (WHO/NMH/NHD/MNM/11.1) Internet: http://www.who.int/vmnis/indicators/haemoglobin.pdf (accessed August 17, 2018).
3. Fortifying flours may cost approximately US$3 per metric ton of flour, whereas fortifying rice may cost US$20 per metric ton of milled rice.
4. FAO. FAOSTAT. 2013 Food Balance Sheets. Internet: http://faostat3.fao.org/ (accessed June 6, 2018).
5. Alavi S, Bugusu B, Cramer G, Dary O, Lee T-C, Martin L, McEntire J, Wailes E (eds.). Rice fortification in developing countries: A critical review of the technical and economic feasibility. Washington, DC: A2Z Project; 2008. Internet: https://www.spring-nutrition.org/sites/default/files/a2z_materials/508-food-rice-fortification-report-with-annexes-final.pdf (accessed June 6, 2018).

USA	Uruguay	Senegal	Myanmar	Others	TOTAL
–	8,100	251	0	126,463	1,397,771
3	2,597	4	0	631	30,275
0	0	0	0	0	80,000
14,210	0	0	74,298	8,564	952,601
68	0	0	0	118	180,301
0	0	0	0	56	68,847
67	9,627	66	0	9,938	139,871
106,248	0	0	3,126	3,362	644,334
0	4,950	7,662	0	999	67,991
5,285	0	0	0	3,511	271,123
75	0	0	0	583	783,098
18,445	14,422	0	0	91,095	1,111,357
144,402	39,696	7,983	77,424	245,319	**5,727,569**

6. Zimmerman SL, Baldwin R, Codling K, et al. Mandatory policy: most successful way to maximize fortification's effect on vitamin and mineral deficiency. Indian J Community Health 2014 Dec;26 Suppl 2:369–74.
7. Although Gabon also imports 100% of its rice, rice is not its primary staple food so it is only estimated that the urban population will be reached through imported rice.
8. Personal communication from Seaboard Mills to David McKee, Key Consulting. 2015.
9. Cambell R, Schiff H, Snodgrass D, Neven D, Downing J, Sturza D. Global food security response: West Africa rice value chain analysis. Washington, DC: U.S. Agency for International Development; 2009.
10. Proportions calculated using the FAO's FAOSTAT 2013 Food Balance Sheets. Mandatory legislation status data from FFI Database.
11. Benin, Côte d'Ivoire, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Nigeria, Senegal and Sierra Leone include some observations adapted from: Rutsaert P, Demont M, Verbeke W. Consumer preferences for rice in Africa. In: Wopereis MCS, Johnson DE, Ahmadi N, Tollens E, Jalloh A, eds. Realizing Africa's rice promise. Wallingford, UK/Boston MA: CAB International; 2013. Internet: http://www.africarice.org/publications/rice_promise/Chap23%209781845938123.pdf (accessed June 6, 2018).
12. Alavi S, Bugusu B, Cramer G, Dary O, Lee T-C, Martin L, McEntire J, Wailes E (eds.). Rice fortification in developing countries: A critical review of the technical and economic feasibility. Washington, DC: A2Z Project; 2008. Internet: https://www.spring-nutrition.org/sites/default/files/a2z_materials/508-food-rice-fortification-report-with-annexes-final.pdf (accessed June 6, 2018).
13. UN Comtrade 2014 import quantities were triangulated with FAO, USDA, and Key Consulting estimates (via importer interviews). Where UN Comtrade aligned with both FAO and USDA, UN Comtrade quantities were used because by-origin-country quantities were available. If UN Comtrade import quantities were not available for a given country then reported export quantities from UN Comtrade 2015 were used instead (Djibouti, Egypt, Gabon, Guinea, Guinea-Bissau, Liberia, Mali, Nigeria, Sierra Leone). For Ghana, UN Comtrade 2013 was the most recent data available. Only countries representing 1% or greater of total rice exports are presented. Abbreviations: MT, metric ton; USA, United States of America.

Country Profiles

Benin

Government programs for fortification of food	
Mandatory fortification programs[1]	**Maize flour** › No
	Oil › Nutrients: Vitamin A
	Salt › Nutrients: Iodine
	Wheat flour › Nutrients: Iron, folic acid
Rice standard	None
Rice consumption patterns	
% who consume it daily:[2]	Unknown
Consumption per person per day (in g):[3]	146
Annual per capita consumption (in kg):[3]	53.4
Characteristics of the rice industry	
Rice production (in tons):[3]	138,000
Cultivation yield (t/ha):[4]	3.42
Area planted with rice (ha):[4]	82,351
Imports (in tons):[3]	894,000
Proportion of local rice industrially milled (%):[5]	<20

Sources:
[1] Global Fortification Data Exchange (GFDx). Internet: http://fortificationdata.org (accessed June 5, 2018).
[2] No known sources of rice consumption coverage in Benin.
[3] FAO. FAOSTAT. 2013 Food Balance Sheets. Internet: http://www.fao.org/faostat/en/#data/FBS (accessed June 6, 2018).
[4] FAO. FAOSTAT. 2016 Crops. Internet: http://www.fao.org/faostat/en/#data/QC (accessed June 6, 2018).
[5] Industrial milling capacity is defined as at least 5 tons rated capacity of paddy rice milling per hour; FFI and GAIN. Feasibility and potential coverage of fortified rice in the Africa rice supply chain. 2016. Internet: http://ffinetwork.org/about/stay_informed/releases/images/Africa_Rice_Executive_summary.pdf (accessed June 15, 2018).

Cape Verde

Government programs for fortification of food	
Mandatory fortification programs[1]	**Maize flour** › No
	Oil › No
	Salt › Nutrients: Iodine
	Wheat flour › Nutrients: Iron, folic acid
Rice standard	None
Rice consumption patterns	
% who consume it daily:[2]	Unknown
Consumption per person per day (in g):[3]	134
Annual per capita consumption (in kg):[3]	48.7

Characteristics of the rice industry	
Rice production (in tons):[3]	None
Cultivation yield (t/ha):[4]	–
Area planted with rice (ha):[4]	–
Imports (in tons):[3]	36,000
Proportion of local rice industrially milled (%):[5]	0 (100% imported)

Sources:
[1] Global Fortification Data Exchange (GFDx). Internet: http://fortificationdata.org (accessed June 15, 2018).
[2] The survey describes urban/rural consumption of rice, but does not describe proportion of households or individuals consuming; Cabo Verde – Inquerito às Despesas e Receitas Familiares 2001–2002. Instituto Nacional de Estatística.
[3] FAO. FAOSTAT. 2013 Food Balance Sheets. Internet: http://www.fao.org/faostat/en/#data/FBS (accessed June 6, 2018).
[4] FAO. FAOSTAT. 2016 Crops. Internet: http://www.fao.org/faostat/en/#data/QC (accessed June 6, 2018).
[5] Industrial milling capacity is defined as at least 5 tons rated capacity of paddy rice milling per hour; FFI and GAIN. Feasibility and potential coverage of fortified rice in the Africa rice supply chain. 2016. Internet: http://ffinetwork.org/about/stay_informed/releases/images/Africa_Rice_Executive_summary.pdf (accessed June 15, 2018).

Côte d’Ivoire

Government programs for fortification of food	
Mandatory fortification programs[1]	**Maize flour** › No
	Oil › Nutrients: Vitamin A
	Salt › Nutrients: Iodine
	Wheat flour › Nutrients: Iron, folic acid
Rice standard	None
Rice consumption patterns	
% who consume it daily:[2]	Unknown
Consumption per person per day (in g):[3]	175
Annual per capita consumption (in kg):[3]	63.6
Characteristics of the rice industry	
Rice production (in tons):[3]	1,290,000
Cultivation yield (t/ha):[4]	2.51
Area planted with rice (ha):[4]	703,413
Imports (in tons):[3]	892,000
Proportion of local rice industrially milled (%):[5]	<20

Sources:
[1] Global Fortification Data Exchange (GFDx). Internet: http://fortificationdata.org (accessed June 15, 2018).
[2] The survey only describes household consumption of cereals in total (rice combined with other cereal grains); Enquete Sure Le Niveau de Vie Des Menges en Côte d’Ivoire 2015. Institut national de la Statistique; 2015.
[3] FAO. FAOSTAT. 2013 Food Balance Sheets. Internet: http://www.fao.org/faostat/en/#data/FBS (accessed June 6, 2018).
[4] FAO. FAOSTAT. 2016 Crops. Internet: http://www.fao.org/faostat/en/#data/QC (accessed June 6, 2018).
[5] Industrial milling capacity is defined as at least 5 tons rated capacity of paddy rice milling per hour; FFI and GAIN. Feasibility and potential coverage of fortified rice in the Africa rice supply chain. 2016. Internet: http://ffinetwork.org/about/stay_informed/releases/images/Africa_Rice_Executive_summary.pdf (accessed June 15, 2018).

The Gambia

Government programs for fortification of food	
Mandatory fortification programs[1]	**Maize flour** › No
	Oil › No
	Salt › Nutrients: Iodine
	Wheat flour › No
Rice standard	None
Rice consumption patterns	
% who consume it (past 3 days):[2]	90
Consumption per person per day (in g):[3]	169
Annual per capita consumption (in kg):[3]	61.8
Characteristics of the rice industry	
Rice production (in tons):[3]	46,000
Cultivation yield (t/ha):[4]	0.74
Area planted with rice (ha):[4]	80,327
Imports (in tons):[3]	69,000
Proportion of local rice industrially milled (%):[5]	0

Sources:

[1] Global Fortification Data Exchange (GFDx). Internet: http://fortificationdata.org (accessed June 15, 2018).

[2] 4,292 out of 4,792 surveyed households reported consuming rice in the three days prior to the survey; Integrated Household Survey Income and Expenditure Poverty Assessment 2010. Gambia Bureau of Statistics, Government of The Gambia.

[3] FAO. FAOSTAT. 2013 Food Balance Sheets. Internet: http://www.fao.org/faostat/en/#data/FBS (accessed June 6, 2018).

[4] FAO. FAOSTAT. 2016 Crops. Internet: http://www.fao.org/faostat/en/#data/QC (accessed June 6, 2018).

[5] Industrial milling capacity is defined as at least five tons rated capacity of paddy rice milling per hour; FFI and GAIN. Feasibility and potential coverage of fortified rice in the Africa rice supply chain. 2016. Internet: http://ffinetwork.org/about/stay_informed/releases/images/Africa_Rice_Executive_summary.pdf (accessed June 15, 2018).

Ghana

Government programs for fortification of food	
Mandatory fortification programs[1]	**Maize flour** › No
	Oil › Nutrients: Vitamin A
	Salt › Nutrients: Iodine
	Wheat flour › Nutrients: Iron, zinc, folic acid, vitamin A,
	vitamin B_{12}, thiamine, riboflavin, niacin
Rice standard	None
Rice consumption patterns	
% who consume it daily:[2]	Unknown
Consumption per person per day (in g):[3]	88
Annual per capita consumption (in kg):[3]	32.0
Characteristics of the rice industry	
Rice production (in tons):[3]	380,000
Cultivation yield (t/ha):[4]	2.82
Area planted with rice (ha):[4]	243,858
Imports (in tons):[3]	656,000
Proportion of local rice industrially milled (%):[5]	30

Sources:
[1] Global Fortification Data Exchange (GFDx). Internet: http://fortificationdata.org (accessed June 15, 2018).
[2] Consumption of rice across households is not described; Ghana Living Standards Survey Round 6. Ghana Statistical Service; 2014.
[3] FAO. FAOSTAT. 2013 Food Balance Sheets. Internet: http://www.fao.org/faostat/en/#data/FBS (accessed June 6, 2018).
[4] FAO. FAOSTAT. 2016 Crops. Internet: http://www.fao.org/faostat/en/#data/QC (accessed June 6, 2018).
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Guinea

Government programs for fortification of food	
Mandatory fortification programs[1]	**Maize flour** › No
	Oil › Nutrients: Vitamin A
	Salt › Nutrients: Iodine
	Wheat flour › Nutrients: Iron, folic acid, niacin, riboflavin, thiamine
Rice standard	None
Rice consumption patterns	
% who consumed rice in the last 7 days:[2]	58.7
Consumption per person per day (in g):[3]	266
Annual per capita consumption (in kg):[3]	97.1
Characteristics of the rice industry	
Rice production (in tons):[3]	1,370,000
Cultivation yield (t/ha):[4]	1.18
Area planted with rice (ha):[4]	1,685,056
Imports (in tons):[3]	368,000
Proportion of local rice industrially milled (%):[5]	0

Sources:
[1] Global Fortification Data Exchange (GFDx). Internet: http://fortificationdata.org (accessed June 15, 2018).
[2] Consumption data were collected for the past seven days; Enquête intégrale sur le budget et l'évaluation de la pauvreté 2002/03. Ministry of Planning, National Directorate of Statistics. Republic of Guinea.
[3] FAO. FAOSTAT. 2013 Food Balance Sheets. Internet: http://www.fao.org/faostat/en/#data/FBS (accessed June 6, 2018).
[4] FAO. FAOSTAT. 2016 Crops. Internet: http://www.fao.org/faostat/en/#data/QC (accessed June 6, 2018).
[5] Industrial milling capacity is defined as at least five tons rated capacity of paddy rice milling per hour; FFI and GAIN. Feasibility and potential coverage of fortified rice in the Africa rice supply chain. 2016. Internet: http://ffinetwork.org/about/stay_informed/releases/images/Africa_Rice_Executive_summary.pdf (accessed June 15, 2018).

Guinea-Bissau

Government programs for fortification of food	
Mandatory fortification programs[1]	**Maize flour** › No
	Oil › Nutrients: Vitamin A
	Salt › Nutrients: Iodine
	Wheat flour › No
Rice standard	None

Rice consumption patterns	
% who consume it daily:[2]	Unknown
Consumption per person per day (in g):[3]	269
Annual per capita consumption (in kg):[3]	98.1
Characteristics of the rice industry	
Rice production (in tons):[3]	140,000
Cultivation yield (t/ha):[4]	1.63
Area planted with rice (ha):[4]	114,426
Imports (in tons):[3]	75,000
Proportion of local rice industrially milled (%):[5]	0

Sources:
[1] Global Fortification Data Exchange (GFDx). Internet: http://fortificationdata.org (accessed June 15, 2018).
[2] No known sources of rice consumption coverage in Mali.
[3] FAO. FAOSTAT. 2013 Food Balance Sheets. Internet: http://www.fao.org/faostat/en/#data/FBS (accessed June 6, 2018).
[4] FAO. FAOSTAT. 2016 Crops. Internet: http://www.fao.org/faostat/en/#data/QC (accessed June 6, 2018).
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Liberia

Government programs for fortification of food	
Mandatory fortification programs[1]	**Maize flour** › No
	Oil › Nutrients: Vitamin A
	Salt › No
	Sugar › Vitamin A
	Wheat flour › Nutrients: Iron, zinc, folic acid, vitamin B_{12},
	thiamine, niacin, riboflavin
Rice standard	None
Rice consumption patterns	
% who consume it daily:[2]	Unknown
Consumption per person per day (in g):[3]	260
Annual per capita consumption (in kg):[3]	94.8
Characteristics of the rice industry	
Rice production (in tons):[3]	180,000
Cultivation yield (t/ha):[4]	1.32
Area planted with rice (ha):[4]	233,788
Imports (in tons):[3]	271,000
Proportion of local rice industrially milled (%):[5]	1

Sources:
[1] Global Fortification Data Exchange (GFDx). Internet: http://fortificationdata.org (accessed June 15, 2018).
[2] Rice consumption is not reported on; Household Income and Expenditure Survey 2014. Liberia Institute for Statistics and Geo-Information Services, Government of Liberia.
[3] FAO. FAOSTAT. 2013 Food Balance Sheets. Internet: http://www.fao.org/faostat/en/#data/FBS (accessed June 6, 2018).
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Mali

Government programs for fortification of food	
Mandatory fortification programs[1]	**Maize flour** › No
	Oil › Nutrients: Vitamin A
	Salt › Nutrients: Iodine
	Wheat flour › Nutrients: Iron, folic acid
Rice standard	None
Rice consumption patterns	
% who consume it daily:[2]	Unknown
Consumption per person per day (in g):[3]	156
Annual per capita consumption (in kg):[3]	57.0
Characteristics of the rice industry	
Rice production (in tons):[3]	1,475,000
Cultivation yield (t/ha):[4]	3.33
Area planted with rice (ha):[4]	834,643
Imports (in tons):[3]	124,000
Proportion of local rice industrially milled (%):[5]	40

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[5] Industrial milling capacity is defined as at least five tons rated capacity of paddy rice milling per hour; FFI and GAIN. Feasibility and potential coverage of fortified rice in the Africa rice supply chain. 2016. Internet: http://ffinetwork.org/about/stay_informed/releases/images/Africa_Rice_Executive_summary.pdf (accessed June 15, 2018).

Mauritania

Government programs for fortification of food	
Mandatory fortification programs[1]	**Maize flour** › No
	Oil › No
	Salt › Nutrients: Iodine
	Wheat flour › Nutrients: Unknown
Rice standard	None
Rice consumption patterns	
% who consume it daily:[2]	96.3
Consumption per person per day (in g):[3]	133
Annual per capita consumption (in kg):[3]	48.4
Characteristics of the rice industry	
Rice production (in tons):[3]	135,000
Cultivation yield (t/ha):[4]	5.25
Area planted with rice (ha):[4]	40,608
Imports (in tons):[3]	179,000
Proportion of local rice industrially milled (%):[5]	Unknown

Sources:
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Nigeria

Government programs for fortification of food	
Mandatory fortification programs[1]	**Maize flour** › Nutrients: Iron, zinc, folic acid, vitamin A,
	vitamin B_{12}, thiamine, niacin, riboflavin
	Oil › Nutrients: Vitamin A
	Salt › Nutrients: Iodine
	Sugar › Nutrients: Vitamin A
	Wheat flour › Nutrients: Iron, zinc, folic acid, vitamin A,
	vitamin B_{12}, thiamine, niacin, riboflavin
Rice standard	None
Rice consumption patterns	
% who consumed rice in the last 7 days:[2]	14.9
Consumption per person per day (in g):[3]	77
Annual per capita consumption (in kg):[3]	28.2
Characteristics of the rice industry	
Rice production (in tons):[3]	3,135,000
Cultivation yield (t/ha):[4]	2.03
Area planted with rice (ha):[4]	2,995,694
Imports (in tons):[3]	2,195,000
Proportion of local rice industrially milled (%):[5]	40

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[1] Global Fortification Data Exchange (GFDx). Internet: http://fortificationdata.org (accessed June 15, 2018).
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Senegal

Government programs for fortification of food	
Mandatory fortification programs[1]	**Maize flour** › No
	Oil › Nutrients: Vitamin A
	Salt › Nutrients: Iodine
	Wheat flour › Nutrients: Iron, folic acid
Rice standard	None

Rice consumption patterns	
% who consume it daily:[2]	Unknown
Consumption per person per day (in g):[3]	144
Annual per capita consumption (in kg):[3]	72.3
Characteristics of the rice industry	
Rice production (in tons):[3]	291,000
Cultivation yield (t/ha):[4]	3.93
Area planted with rice (ha):[4]	225,324
Imports (in tons):[3]	1,120,000
Proportion of local rice industrially milled (%):[5]	40

Sources:
[1] Global Fortification Data Exchange (GFDx). Internet: http://fortificationdata.org (accessed June 15, 2018).
[2] The survey does not include consumption data; Senegalese Household Survey 2001–2002. National Agency of Statistics and Demography (Senegal).
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[4] FAO. FAOSTAT. 2016 Crops. Internet: http://www.fao.org/faostat/en/#data/QC (accessed June 6, 2018).
[5] Industrial milling capacity is defined as at least five tons rated capacity of paddy rice milling per hour; FFI and GAIN. Feasibility and potential coverage of fortified rice in the Africa rice supply chain. 2016. Internet: http://ffinetwork.org/about/stay_informed/releases/images/Africa_Rice_Executive_summary.pdf (accessed June 15, 2018).

Sierra Leone

Government programs for fortification of food	
Mandatory fortification programs[1]	**Maize flour** › No
	Oil › Nutrients: Vitamin A
	Salt › No
	Wheat flour › Nutrients: Iron, zinc, folic acid, vitamin A, vitamin B_{12},
	thiamine, niacin, riboflavin
Rice standard	None
Rice consumption patterns	
% who consume it daily:[2]	Unknown
Consumption per person per day (in g):[3]	283
Annual per capita consumption (in kg):[3]	103.3
Characteristics of the rice industry	
Rice production (in tons):[3]	837,000
Cultivation yield (t/ha):[4]	2.07
Area planted with rice (ha):[4]	754,113
Imports (in tons):[3]	279,000
Proportion of local rice industrially milled (%):[5]	7

Sources:
[1] Global Fortification Data Exchange (GFDx). Internet: http://fortificationdata.org (accessed June 15, 2018).
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[3] FAO. FAOSTAT. 2013 Food Balance Sheets. Internet: http://www.fao.org/faostat/en/#data/FBS (accessed June 6, 2018).
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[5] Industrial milling capacity is defined as at least five tons rated capacity of paddy rice milling per hour; FFI and GAIN. Feasibility and potential coverage of fortified rice in the Africa rice supply chain. 2016. Internet: http://ffinetwork.org/about/stay_informed/releases/images/Africa_Rice_Executive_summary.pdf (accessed June 15, 2018).

Introduction to Rice Fortification

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Key Messages

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

Introduction

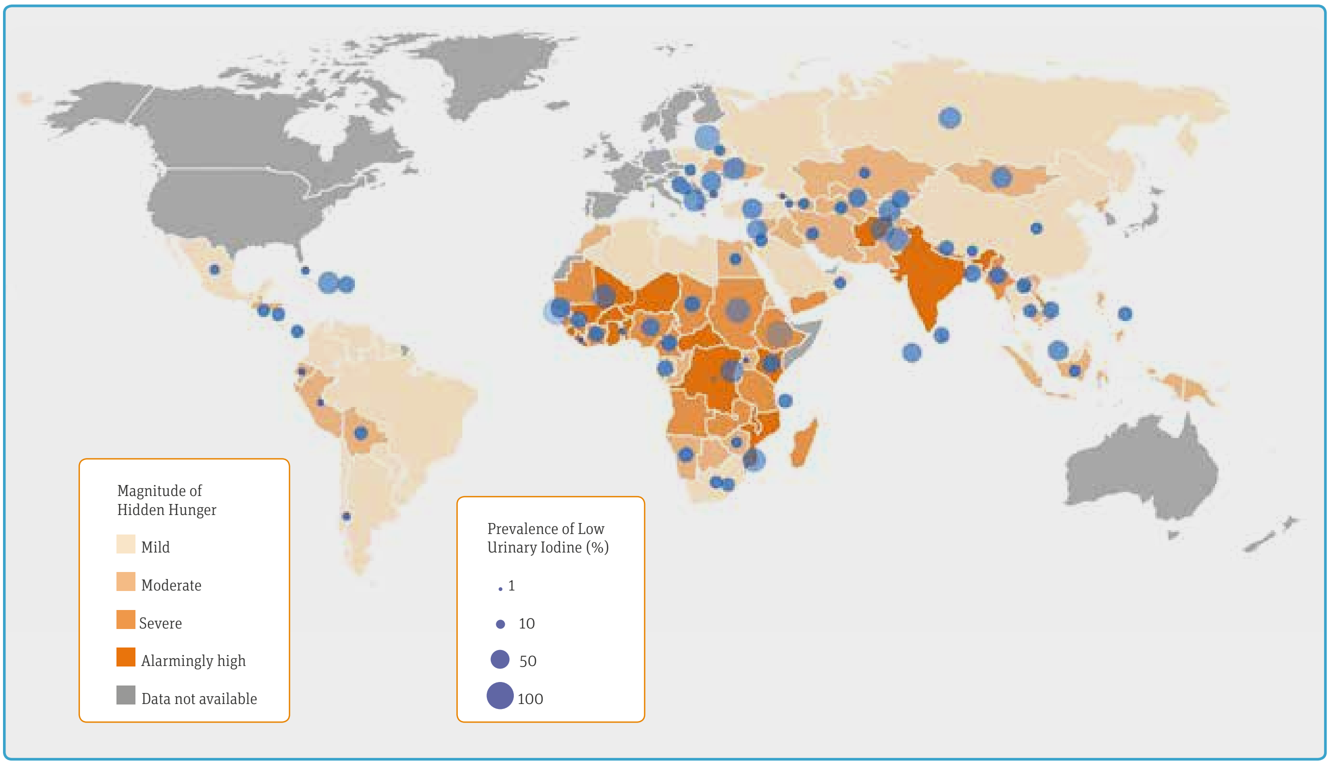
Micronutrient deficiencies affect more than two billion people worldwide and are especially prevalent in developing countries. Also referred to as hidden hunger, micronutrient deficiencies impair physical growth and cognitive development and have long-term effects on health, learning ability and productivity.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

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

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

The Lancet 2008[4] and 2013[5] Maternal and Child Nutrition Series, the Copenhagen Consensus,[6] and the 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

FIGURE 1: Hidden Hunger Map[8]



one-third of global child deaths per year and, in Asia and Africa, to boost GDP by up to 11%.[7]

This article provides an overview of large-scale rice fortification and highlights important considerations for its introduction, implementation and scale-up. For definitions of the terminology presented in this article, please refer to the glossary (p. 111).

The 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, and dairy as well as legumes, cereals, fruits and vegetables) is neither consistently available nor consumed in sufficient quantities. In addition, gut inflammation and illnesses (such as diarrhea, malaria, helminthiasis [worms], TB and HIV/AIDS) affect a person's ability to absorb micronutrients and can lead to deficiencies. In low- and middle-income countries (LICs and MICs), multiple micronutrient deficiencies tend to coexist as they share common causes.[5]

Although more prevalent in LICs and MICs, micronutrient deficiencies also represent a public health problem in industrialized nations and in populations suffering from overweight and obesity. The increased consumption of highly processed, energy-dense yet 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 10 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 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.

FIGURE 2: Two-step rice fortification manufacturing process

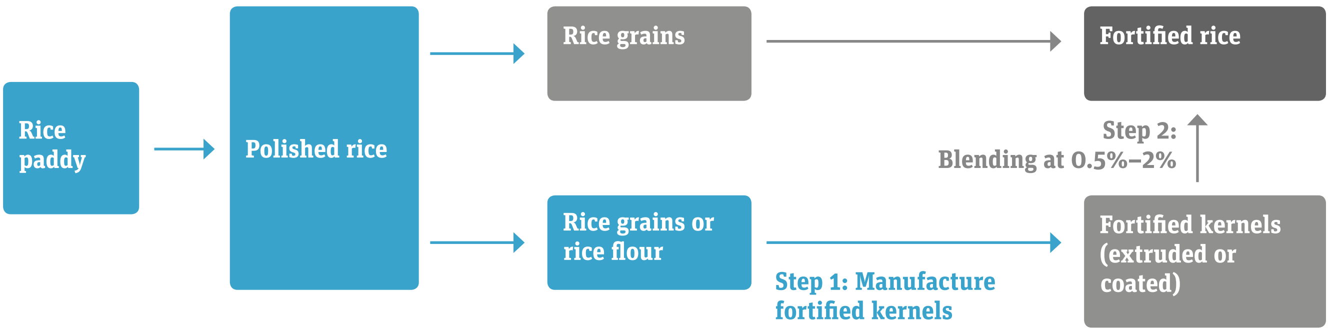


Chart adapted from Steiger 2012

Rice fortification builds upon the global success and long-established evidence base for safe and effective flour and salt fortification programs. Wheat and maize flour have been successfully fortified with iron, folic acid and other micronutrients for more than 60 years. Salt's nearly century-old history of fortification with iodine has resulted in a dramatic reduction in global iodine deficiency. From a regulatory, public health and nutrition point of view, rice fortification is very similar to maize and wheat flour fortification. However, from an implementation and technical perspective, fortifying rice differs significantly from fortifying flour.

Rice fortification, like other food fortification, should be one component of a larger integrated and multisectoral strategy to improve micronutrient health that aims to improve dietary diversity and infant and young child feeding practices. This is because the consumption of fortified foods on their own will fall short of fulfilling micronutrient gaps for groups with relatively high micronutrient needs.

For example, target populations such as young children and pregnant or lactating women will require additional micronutrient supplementation to meet their requirements. In addition, improved sanitation, good hygiene practices and accessible and high-quality preventive and curative health services are essential to sustain a population's good micronutrient health.

In the 1940s, the Philippines began fortifying rice with thiamine, niacin and iron. This resulted in the successful elimination of beriberi, a severe public health problem caused by thiamine deficiency. In 1952, the Philippines pioneered the first mandatory rice fortification legislation requiring all rice millers and wholesalers to enrich the rice they milled or traded.[9]

Since these early efforts, the past decade has seen a significant evolution of cost-effective rice fortification technologies that are unlocking opportunities to 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 manufacturing of fortified kernels containing appropriate vitamins and minerals, and blending the fortified kernels with milled rice to create fortified rice. 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.

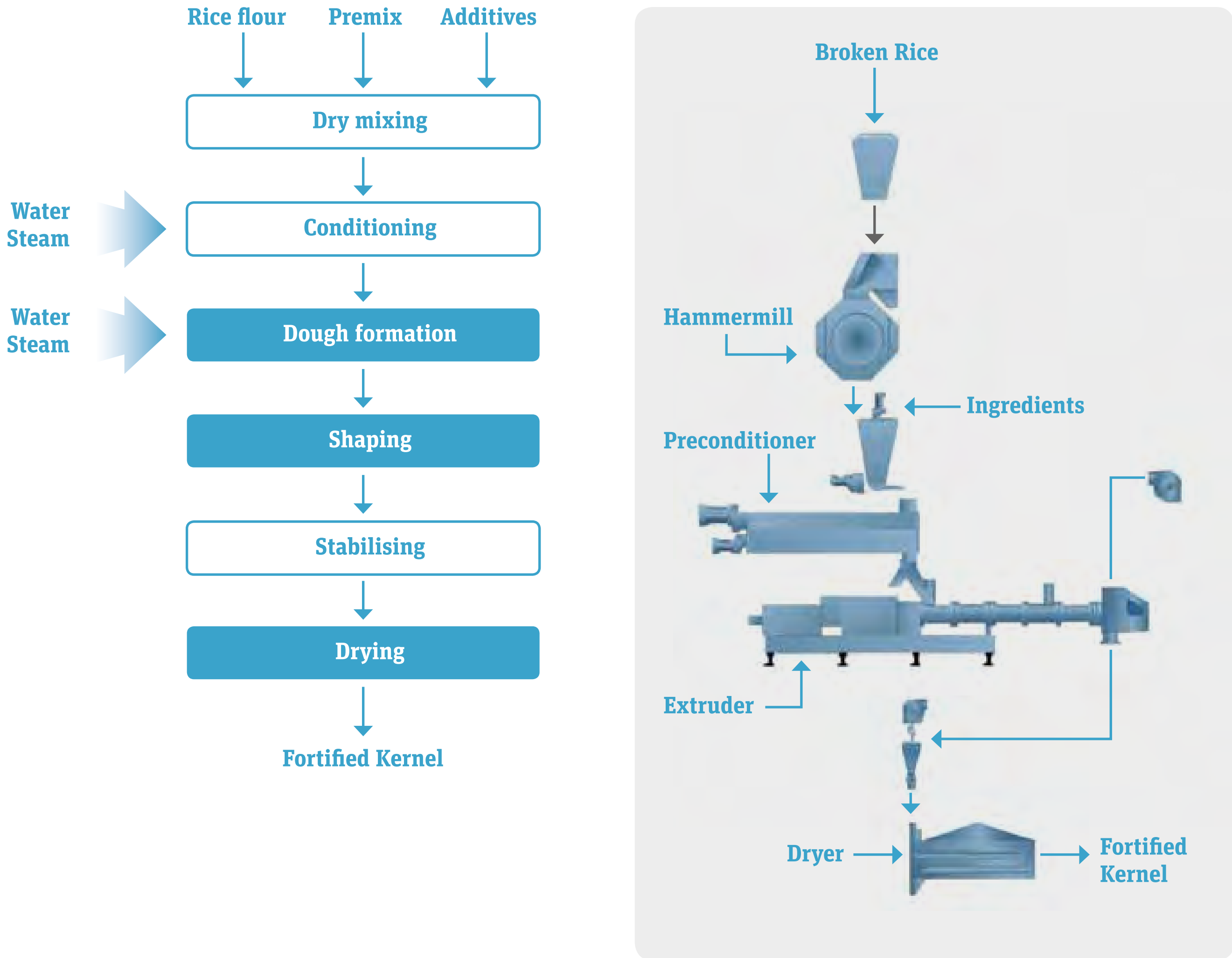
Extrusion and rinse-resistant coating technologies produce fortified rice that is effective and acceptable to consumers in color, taste and texture. Although a third fortification technology – dusting – is used in the United States and a few other countries, it provides limited nutrient protection when rice is washed, soaked or cooked in excess water that is then discarded. Dusting is appropriate in countries where rice is not washed prior to cooking, nor cooked in excess water.

Fortified kernel production technologies

Coating

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

FIGURE 3: Basic extrusion steps



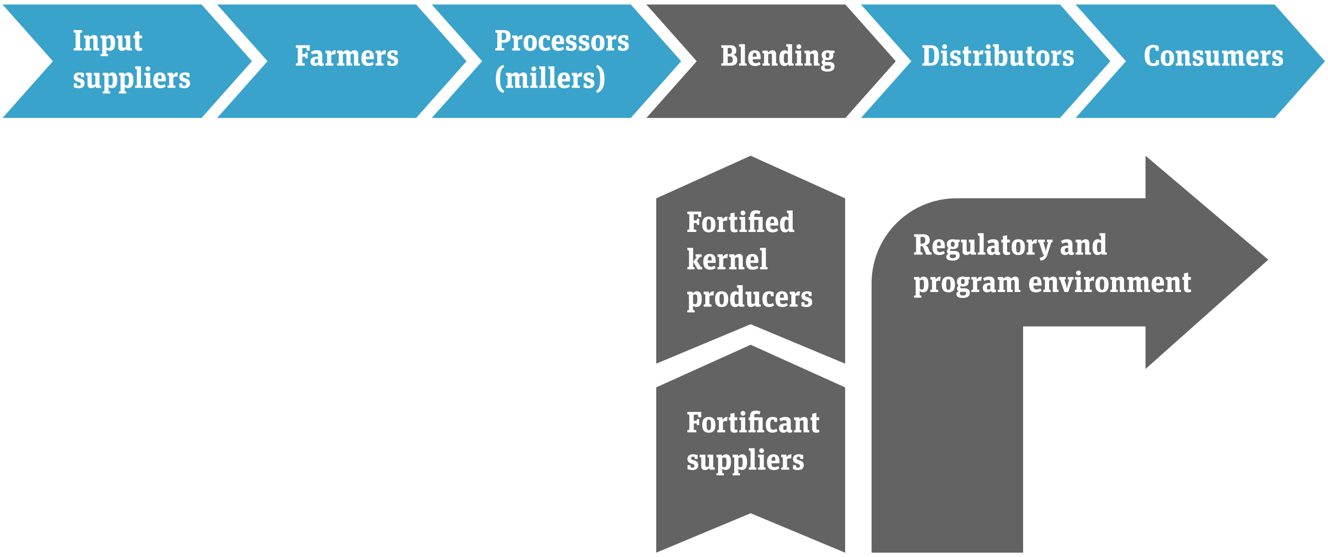
is evenly spray-coated with micronutrients and the additional ingredients. This is usually done in large rotational drum or pan-coating machines. The coated kernels are then dried to yield fortified kernels. This technology concentrates the micronutrients on the surface of the rice grains. When cooked, 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. This method of producing fortified kernels is not recommended when rice is cooked in excess water that is later discarded.

Extrusion

Extruded fortified kernels are formed by combining water and a fortificant mix with rice flour that is usually made from grinding lower value and non-contaminated broken rice to form a dough (**Figure 3**). 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.

Although initially extrusion was done at room temperature ('cold extrusion'), this approach has been all but abandoned in favor of the use of heat for improved sensory properties and kernel stability. Hot extrusion (60°C–110°C) uses equipment of various degrees of sophistication – from steam-enhanced pasta presses to large-scale double screw extruders – to 'shape' the dough into kernels that more closely resemble non-fortified rice. The process may include a preconditioner and an emulsifier (monoglyceride) added to maintain stability during storage of the fortified kernels. The resulting fortified kernels closely resemble different types of rice, with various degrees of translucency and texture.[2] Fortified kernels made via hot extrusion are similar to non-fortified rice in their uptake of water during cooking, cooking time and firmness.

FIGURE 3: Rice fortification supply chain



Blending process

As shown in **Figure 4**, when rice fortification is introduced, the rice supply chain is adapted to incorporate fortified kernel production and blending. The blending ratio, typically between 0.5% and 2%, depends on the nutrient content of the fortified kernels, the desired level of fortification, and organoleptic and consumer acceptance considerations. Quality assurance and quality control are needed to ensure uniform blending at the correct ratio.

Integrating rice fortification into the rice supply chain

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

Recommended micronutrients for inclusion in fortified rice

From a public health and nutrition point of view, the research and recommendations related to wheat flour fortification can also be applied to rice fortification. However, it is important to consider the differences between rice and flour in terms of nutrient content and any technological aspects that warrant changes of the recommendations when fortifying rice instead of flour. Based on the evidence available, it is advisable to consider fortification with the following micronutrients: iron, vitamin A, vitamin B_9 (folic acid), vitamin B_6 (pyridoxine), vitamin B_{12} (cobalamin), vitamin B_1 (thiamine), vitamin B_3 (niacin) and zinc.[10] Among these and upon reviewing the evidence, the World Health Organization (WHO) has singled out iron fortification as a strong recommendation and vitamin A and folic acid as conditional recommendations. Overall, the determination of which micronutrients to include and at what level depends on the target population's micronutrient intake, the prevalence of micronutrient deficiencies and the population's access to, and consumption of, other fortified foods. Each country introducing rice fortification will need to develop fortification standards, taking into account its local micronutrient situation and existing micronutrient interventions. Wherever appropriate and feasible, regional standards may benefit countries with similar fortification needs from a scale and trade perspective. For additional information on the evidence for recommended micronutrients and standards, please refer to the WHO Guideline on rice fortification[11] as well as the contributions of de Pee et al (Evidence, p. 55 and Standards, p. 63).

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

Extruded fortified rice

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. Other interventions such as iron/folate or multiple micronutrient supplementation will therefore still be required. Young children aged six to 23 months, likewise, have relatively high micronutrient needs yet consume only small quantities of rice. Therefore, fortified rice will not be sufficient to fill their micronutrient gaps. For additional information on specific micronutrient needs across the lifecycle, please refer to Figure 4 in the contribution by Rudert et al (p. 87).

> "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"

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, whereby 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.

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

Voluntary fortification is a market-driven approach in which fortified rice is marketed as a 'value-added' product to consumers. This delivery option has limited potential to achieve a significant public health impact as it relies on consumer awareness, demand generation and the willingness and ability to pay slightly more for the fortified rice. For additional information on delivery options for fortified rice, please refer to the contribution by Codling et al (p. 68).

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.[12]

Rice fortification costs fall into two main categories: program costs and supply chain costs. The former are typically incurred by the public and social sectors – governments, funders, program implementers and regulatory agencies – while the latter are usually borne by the private sector – fortified kernel producers, rice millers, food companies and retailers. During the introductory phase of rice fortification, costs will be incurred for mobilizing stakeholder support, conducting a rice landscape analysis, developing a business case, carrying out trials for logistical feasibility and consumer acceptability, policy development and general project management. The rice landscape analysis will inform strategic decisions regarding the source and production of fortified kernels, blending locations, delivery options and the scale of operations. During the implementation phase, capital investments will be needed and recurring costs will be incurred for the production and distribution or sale of fortified rice. Recurring costs include fortified kernel production, transportation, blending, quality assurance and quality control, as well as continuing policy development and general project management. In the scale-up phase, fortified rice production and distribution expand. This expansion should result in greater efficiency of the supply chain and economies of scale.

Conclusion

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

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

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2. 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. 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.
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Overview of Evidence and Recommendations for Effective Large-scale Rice Fortification

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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. 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 micronutrient needs, the following micronutrients are recommended for rice fortification: iron, zinc, and vitamins A, B_1 (thiamine), B_3 (niacin), B_6 (pyridoxine), B_9 (folic acid), and B_{12} (cobalamin), which is also in line with the very recently published WHO guideline on the fortification of rice with vitamins and minerals as a public health strategy.[1,2]
- Based on results of very recent studies, novel formulations for optimized bioavailability of iron and zinc can further optimize nutrient delivery.
- 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 the 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

Schoolchildren participating in a school feeding trial in northern Ghana (Tamale)

and implementation of appropriate food fortification programs and is particularly helpful for low- and middle-income countries.[3] The WHO/FAO publication provides guidance on the selection of food vehicles and which micronutrients to add, in what chemical form, and in what quantities. In addition, WHO recently published the guideline *Fortification of Rice with Vitamins and Minerals as a Public Health Strategy*, which supports rice fortification and recommends that decisions on which micronutrients to add and in what amount are, among other things, based on nutritional needs and gaps in dietary intake of the target population.[1]

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

Requirements for rice fortification to be effective

For a rice fortification program to be effective, the following conditions need to be met (see **Figure 1**):

a) The micronutrients used to fortify the rice should remain stable during storage, i.e., losses over time should be limited.

b) The micronutrients should be retained after preparation (washing, cooking and discarding excess water).

c) The fortified rice should be acceptable to the consumer in appearance (shape and color), taste and smell.

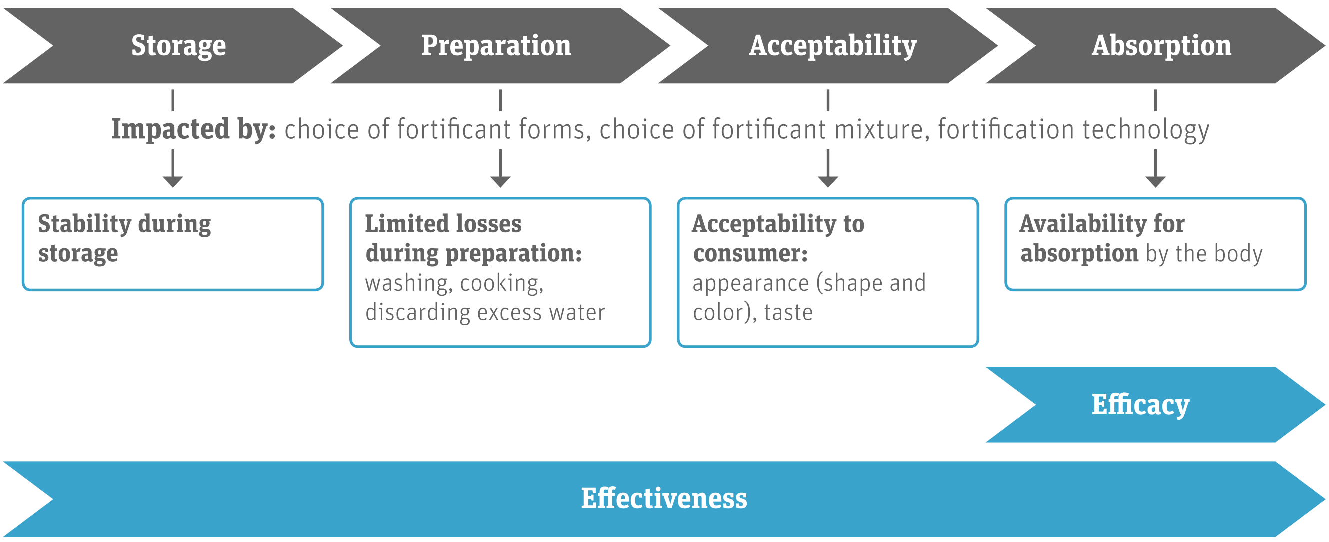
d) The micronutrients remaining post-cooking should be available for absorption by the body.

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

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



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, the 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, 16 efficacy studies have been published that assessed the impact of fortified rice on micronutrient status or absorption.[4–20] All studies except one used fortified kernels that were produced using extrusion technology. One pilot study was conducted with coated rice fortified with ferrous sulfate ($FeSO_4$).[17] Each study was conducted in a controlled setting and aimed to compare impact on micronutrient status among individuals who received fortified rice versus individuals who received non-fortified rice, rice with micronutrients added after cooking, and/or micronutrients provided in supplement form. In 10 of the studies the rice was fortified only with iron, in one study only with vitamin A,[20] and in five studies a combination of micronutrients was used, i.e., iron, zinc, and vitamin A in the studies by Pinkaew et al;[13,14] iron, zinc, vitamins A, B_1, B_6, and B_{12} and folic acid in the study by Thankachan et al;[15] iron, zinc, vitamins B_1, and folic acid and in part vitamins B_3, B_{12}, B_6, and A by Perignon et al;[19] and iron, zinc, folic acid, and vitamin B_1 by Della Lucia et al.[18] The studies were conducted in low- and middle-income countries including the Philippines, India, Nepal, Thailand, Mexico, Brazil and Cambodia, while the study with coated rice was conducted in iron-deficient anemic subjects in the USA. Study populations included children aged 6–23 months, preschool and school-age children, women of reproductive age, and anemic individuals.

Iron results

Fourteen of the 15 efficacy studies on iron-fortified rice used ferric pyrophosphate (FePP) as the iron form. One of them also included a group that received ferrous sulfate[4] and a pilot study used ferrous sulfate ($FeSO_4$) to fortify rice using coating technology.[17] Although FePP is not the most bioavailable iron fortificant, it has so far been the only type of 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 (see below).[16] The amount of fortified rice that was provided in the different 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. Fourteen of the 15 studies with rice fortified with iron assessed impact on hemoglobin concentration or anemia. None of the studies found a negative impact, while six found an increase in status. Nine of the 11 studies that assessed iron status found an increase. In total, 13 of the 14 studies found a positive impact on either hemoglobin concentration or iron status, or on both. 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 received iron supplements until a few months before the study started.[15]

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 multifactorial causes of anemia. As other nutritional and non-nutritional causes also affect anemia, there are limits to the impact of iron on hemoglobin concentration.

Recent findings for further improving iron bioavailability

Recent studies have shown the possibility to further enhance the bioavailability of iron in both extruded and coated rice by using a mixture of citrate and trisodiumcitrate as solubilizing agents. During rice cooking, this moiety solubilizes ferric pyrophosphate within the grain and renders it more soluble *in vitro* and more bioavailable in human subjects.[16] These findings have been confirmed in a second trial in which it was also applied to coated rice, in which bioavailability was found to be almost as good as in hot extruded rice. In view of these results, the possibility arises to use lower iron fortification levels for rice when containing the solubilizing agent citrate/trisodiumcitrate compared with formulations containing micronized ferric pyrophosphate (see **Table 1** in the article in this magazine on specifications and standards, p. 66) and to also apply it to coating technology.

Another relevant finding with regard to iron bioavailability from fortified rice is that zinc oxide (ZnO) tends to lower it, which is not seen when using zinc sulfate (ZnSO4) as a zinc fortification compound.[22,23] It should be noted though that it has been reported that zinc sulfate decreases the stability of vitamin A in rice slightly faster than zinc oxide,[24] which would be important to consider when rice is also fortified with vitamin A. The study on the impact of zinc compounds also found that iron bioavailability when EDTA was added in combination with zinc oxide was comparable to the combination of citrate/trisodiumcitrate and zinc sulfate as well as to when ferrous sulfate was added to the rice meal (gold standard for assessing iron bioavailability). The sensory attributes were also comparable. While those findings on zinc compounds and EDTA likely offer further possibilities for optimizing iron bioavailability from rice at lower levels, they have as yet been reported by one multiple meal stable iron isotope absorption study[23] and we await further studies to confirm the findings.

When considering fortification of rice with iron at scale, cost and consumer acceptability are key. Blending ratio as well as level and choice of iron fortificant 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. When using micronized ferric pyrophosphate, the concentration of iron cannot exceed 7 g/kg without imparting color. 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. However, the novel formulations described above offer the possibility for lower iron fortification levels, further reducing the risk of changing color and ensuring acceptability while maintaining high bioavailability.

Vitamin A results

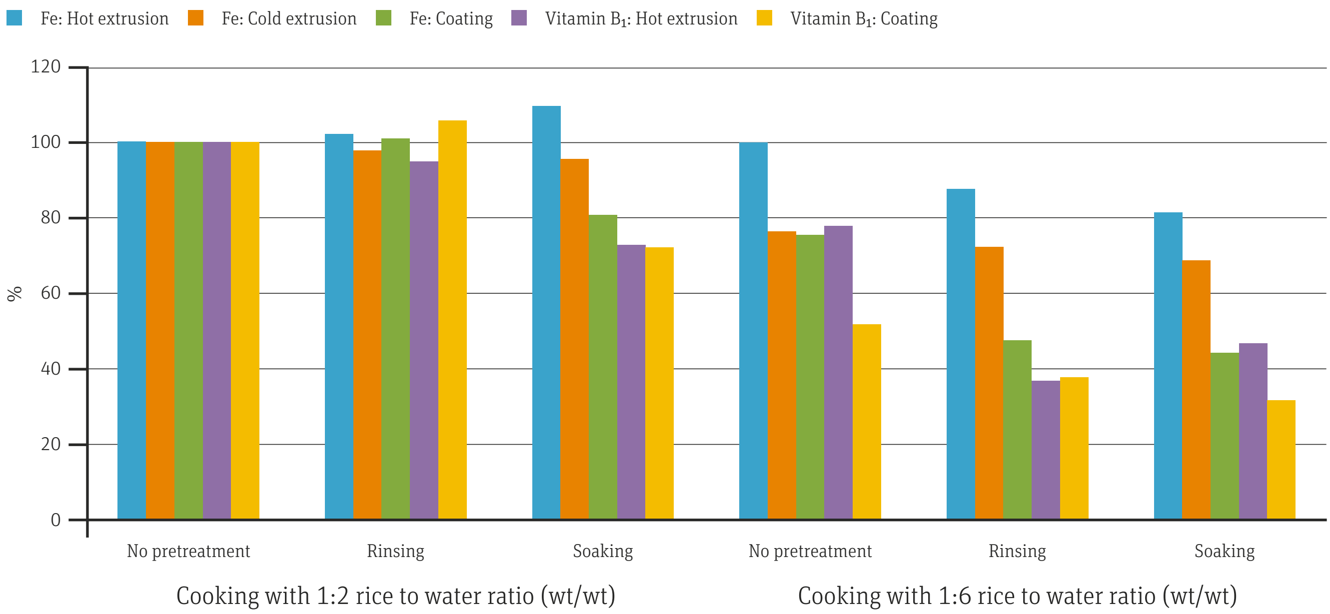
Five studies included rice fortified with vitamin A, four of which were also fortified with other micronutrients. The one study that fortified rice only with vitamin A was conducted among night-blind pregnant women in Nepal and provided study groups with different sources and levels of vitamin A.[20] 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 four studies were conducted among schoolchildren. In three of the studies the children had an average baseline serum retinol concentration considered indicative of adequate, or close to adequate, vitamin A status.[13,14,15] In those studies, the serum retinol concentration did not increase further due to homeostatic regulation. However, the one study that also measured total body retinol reported an improvement.[14] A large efficacy study in Cambodia including 2,440 schoolchildren (FORSICA trial) was effective in improving vitamin A status and in decreasing vitamin A deficiency compared to the control group.[19]

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 and consumed in sufficient quantities, it may not be necessary to also fortify rice with vitamin A, and its stability is also likely lower in rice compared to cooking oil.[25]

Results with other micronutrients

The impact of fortification of rice with zinc, folic acid, vitamins B_1 (thiamine) and B_{12} on micronutrient status has also been assessed. Thankachan et al[15] studied rice fortified with iron, zinc, vitamins A, B_1, B_6, and B_{12} and folic acid. In a study by Pinkaew et al,[13] impact on zinc status by rice fortified with iron, vitamin A and zinc was assessed. Thankachan et al found an improvement of vitamin B_{12} status and a decrease of homocysteine levels.[15] This indicated that both vitamin B_{12} and folic acid were well absorbed and utilized. They found no change of indicators of thiamine or zinc status. Thiamine status was already sufficient.

FIGURE 2: Retention (%) of iron and vitamin B_1 by cooking procedure (in 1:2 rice to water ratio, absorption method, and with 1:6 rice to water ratio, excess water with different pretreatments). The retention with no pretreatment with the absorption method is by definition 100% [20]



A recent study investigated the bioavailability of folic acid from pectin-coated rice. Folic acid absorption was slightly lower than that of the reference given in aqueous solution, but these results also support the view that folic acid can be readily absorbed from fortified rice, which was coated rice in this case. The absence of impact of zinc fortification on serum zinc concentration, which has also been reported by other studies, 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 et al[13] reported a decline of zinc deficiency in both the intervention and the control groups. The decline of serum zinc concentration was smaller in the fortified rice group compared with the unfortified rice group.[13] In addition, a recent study from a school feeding program in Brazil showed improvements in serum zinc and serum folate as well as for erythrocyte thiamine compared to the control group receiving unfortified rice.[18]

Stability and retention of micronutrients in fortified rice during cooking

Minerals

As shown in **Figure 2**, the losses of minerals during preparation, i.e., pretreatment (rinsing or soaking) and cooking, range from being negligible with no pretreatment and using the absorption method (1:2 rice to water ratio wt/wt) to more important losses (up to 55%) when cooking in excess water and soaking the rice prior to cooking. Generally, irrespective of rice fortification technology (hot or cold extrusion, coating) and the pretreatment step (rinsing, soaking, no pretreatment), when rice was prepared with the absorption method, retention exceeded 80%. When rice was prepared by discarding excess cooking water, losses were greater (up to 55%), with higher retention found for hot extrusion followed by cold extrusion and coating, in this order. In these circumstances, the pretreatment contributed to the lower retention.[21]

Water-soluble vitamins

As a proxy of water-soluble vitamins, vitamin B_1 was used in a recent study commissioned by WFP/USDA. The retention followed a similar pattern to the one for minerals, but tended to be lower with excess water (lowest retention 31% when cooking in excess water and soaking the rice prior to cooking). Rinsing *per se* did not affect the retention in hot or coated rice, whereas soaking reduced retention by 30%, also when cooking with the absorption method (see **Figure 2**).

Acceptability studies with fortified rice

Several acceptability studies have been conducted over the years investigating acceptability and ability of consumers to distinguish fortified from unfortified rice. In general, as only a very small proportion of the kernels in fortified rice are fortified (0.5%–2%) and the color change by ferric pyrophosphate is minimal, no differences in rice appearance between fortified and unfortified rice have been reported. [28,10,5] In a larger acceptability study in Vietnam and Cambodia, fortified rice could correctly be identified by participants, but was found to be highly, and sometimes even more, acceptable.[29]

Recently, extruded and coated rice formulations including the novel solubilizing agent citrate/trisodium citrate have been tested for their acceptability in Cambodia. The results show a high degree of acceptability of the rice among women and school children, as measured by the degree to which they finished the rice meal and the total intake of rice over a week. Consumers liked the rice and identified small differences in the appearance of different fortified rice products produced by different manufacturers.[30]

These results indicate that fortified rice, when produced according to specifications and guidelines (see **Table 1** in the article in this magazine on specifications and standards, p. 66), can be well accepted across a range of settings and products. Nonetheless, it is always good practice to assess retention under the locally prevailing preparation methods and consumer acceptability of the actual fortified rice product that will be introduced, as the application of specific production methods can vary substantially among manufacturers. Furthermore, it is important to ensure that the fortified kernels match the shape, appearance and color of the rice to be fortified.

Effectiveness studies – impact of rice fortification under programmatic circumstances

Four studies analyzed the effectiveness of rice fortification under less controlled, more programmatic, circumstances.[31–34] The first study, conducted in the Philippines in 1947–1949, used coated rice fortified with thiamine, niacin and iron. Results showed a substantial reduction of beriberi, a well-known consequence of thiamine deficiency, as well as a lower incidence of infant deaths in the areas that received fortified rice.[34] 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.[32] 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.[33] 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.[31]

> "The above evidence supports the fortification of rice with iron, vitamin A, folic acid, vitamin B_{12} and thiamine, and the addition of zinc, niacin and vitamin B_6 is also recommended"

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 B_{12} and thiamine. Zinc is also recommended, although two studies 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.[27] For niacin and vitamin B_6, 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,[35] restoring nutrient levels lost during milling is good practice.[1] Bioavailable forms of these nutrients exist and adding them to rice together with the other micronutrients does not markedly increase the cost of fortified rice.

Research and development

Further research to further optimize the mineral absorption from rice is currently ongoing. Recent results have shown ways to increase iron bioavailability (see iron section above) which is important for safeguarding the impact on iron while maintaining good consumer acceptability.

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 p. 48), and in the paper on standards by de Pee, Moretti and Fabrizio (see p. 63). 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 with micronutrient content within the permitted range of variation, and they are blended at the required ratio. In addition, stability testing needs to be conducted under prevailing storage, preparation and cooking conditions to assure content remains adequate.

- **Monitoring of coverage 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. When this is ascertained, changes of micronutrient status are likely.

- **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 over time and/or whether additional measures may be required.

"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, B_1 (thiamine), B_6 and B_{12}, 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 on the public health significance of the deficiencies of these micronutrients. In addition, consideration can be given to the feasibility of adding specific fortificants while maintaining consumer acceptability and stability during storage. Countries should therefore focus on ensuring appropriate fortification (i.e., suitable fortified kernels that blend in well with unfortified rice, implementing blending at desired ratio), storage and distribution, and monitoring acceptance and consumption (adequate quantities and by different subgroups).

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Standards and Specifications for Fortified Rice

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Key Messages

- Standards and specifications for fortified rice should specify quality in terms of safety, acceptability (organoleptic and optical) 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.
- The recently published WHO guideline *Fortification of Rice with Vitamins and Minerals as a Public Health Strategy* supports rice fortification and recommends that decisions on which micronutrients to add and in what amount be, among other things, based on nutritional needs and gaps in dietary intake of the target population.[1]
- 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, it is a good approach to set the micronutrient level of fortified rice such that, at prevailing consumption levels, it provides the EAR for adults.[2,3]

Introduction

When a country chooses to fortify rice to increase micronutrient intake across the population, standards that specify the required quality, the visual and organoleptic characteristics and the nutrient content provide clarity and protection for both manufacturers and consumers. They also ensure acceptability. 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 a government contract 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 required chemical form and composition of the micronutrients, the technology or technologies used to produce fortified kernels, the visual characteristics of the 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 Com-

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)

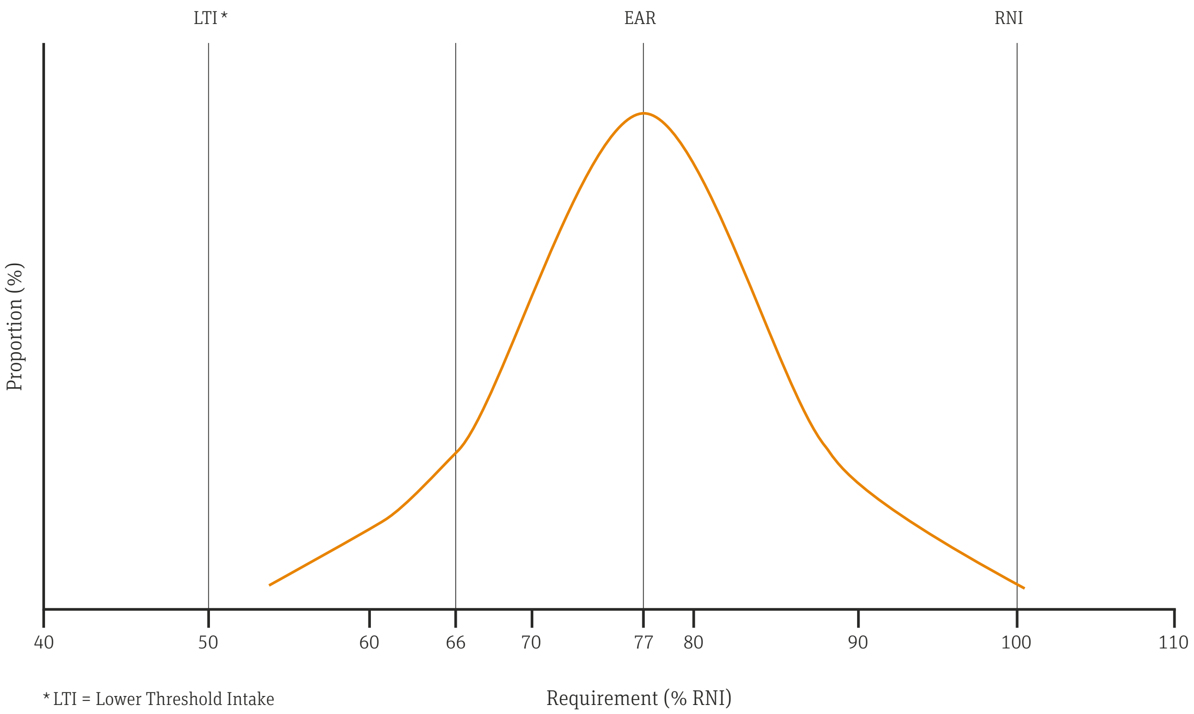
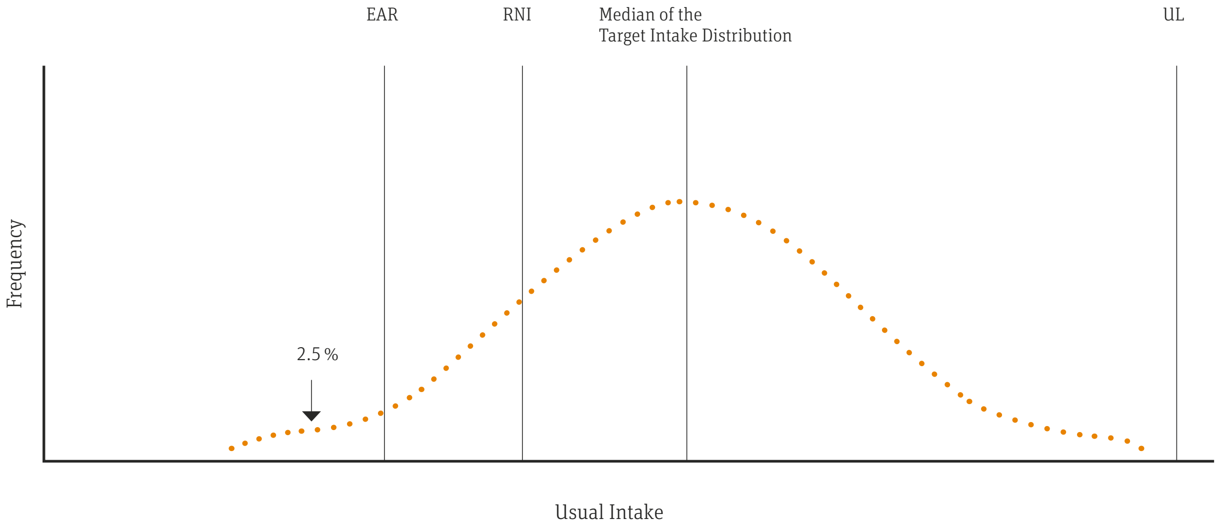


FIGURE 2: The target for micronutrient intake distribution, where 2.5% or less is below the EAR and the majority is above the RNI but below the tolerable upper limit (UL)



mission develops harmonized international food standards, guidelines and codes of practice to protect the health of consumers and ensure fair trade practices. The Commission also promotes coordination of all food standards work undertaken by international governmental and nongovernmental 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 198-1995)[4] and the guideline for the addition of essential nutrients to foods (CAC/GL 09-1987, amended in 1989 and 1991)[5], 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 should then develop specifications for individual fortified foods, such as fortified rice, that are for a particular use, such as school feeding, or for particular contracts. These specifications can include more details (e.g., micronutrient content, 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 consumer representatives (e.g., civil society organizations). Countries that have developed a standard for fortified rice include Costa Rica, the Philippines, and the USA.

Setting the micronutrient content

The level of micronutrients for fortified rice should be determined after consideration of four country-specific conditions.[6]

- **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 more or less the same group of the population that will consume the fortified rice, vitamin A may be included at a lower level in the fortified rice, or not at all. Also, when more than one staple food is fortified, e.g., wheat flour and rice, the fortification level of each should be based on their combined intake so that micronutrient intake will be the same whether 300 g of one of the staples or 150 g of each is consumed per day.

- **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).[7]

- **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 visual 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 consume 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 typically 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.

It is important to 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 so that the amount of rice that is typically consumed per capita per day provides 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 daily consumption of 1–10 kg (depending on the micronutrient) of uncooked rice 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 the EAR requires an estimate of the per capita rice consumption. For example, the EAR for vitamin B_1 (thiamine) is 0.9 mg

TABLE 1: Nutrient levels proposed for fortified rice at moment of consumption (mg/100 g[2])

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	
	Ferric pyrophosphate with citrate and trisodium citrate, possibly other solubilising agents [a,b]	7	7	4	4	
Folic acid (B_9)	Folic acid	0.50	0.26	0.13	0.10	0.192
Cobalamin (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)
Thiamine (B_1)	Thiamine mononitrate	2.0	1.0	0.5	0.35	0.9 (f) 1.0 (m)
Niacin (B_3)	Niacin amide	26	13	7	4	11 (f) 12 (m)
Pyridoxine (B_6)	Pyrodoxine hydrochloride	2.4	1.2	0.6	0.4	1.1

[a] Reported effective molar ratio Fe/citrate/trisodium citrate: 1/0.1/2.1.
[b] See article by Saskia de Pee, Diego Moretti, Cecilia Fabrizio and Jennifer Rosenzweig on p. 55 of this supplement for evidence.

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 thiamine. 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.[7] The same categories were 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 thiamine, a level of 0.5 mg/100 g is proposed for the category of 150–300 g/d and 0.35 mg/100 g for >300 g/d, as these would provide approximately 1.0 mg of thiamine 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 choosing the eight recommended micronutrients for fortification of rice, see Rice fortification by de Pee et al, p. 55.[3] This recommendation by de Pee is also in line with the very recently published WHO guideline on rice fortification, which recommends that micronutrients for fortification of rice be selected based on nutritional needs and gaps in dietary intake, that reconstitution of intrinsic levels of thiamine, niacin, vitamin B_6 and riboflavin that have been lost due to milling should remain a regular practice in fortification, that iron status can benefit from fortification with iron and vitamin A and folate nutritional status from fortification with folic acid, and that vitamin B_{12} should also be added when folic acid is added.[1] It is important to note though that addition of riboflavin would color the fortified kernel yellow, making the fortified kernels easy to pick out, and intrinsic levels of riboflavin are already low, so that its addition is not recommended.

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 that has higher levels of thiamine, niacin, and vitamin B_6 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. Similar considerations can be applied when other staple foods, such as wheat flour or maize flour, are fortified – in which case, fortification level should be set based on the per capita daily intake of the different staples together.

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 of the vitamins and will require the highest overage. 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 fortified 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)[8] 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 data that need to be collected by both a food frequency 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 buys for the social safety net program) aim to protect the health of consumers, guarantee high quality of fortification practices and products and 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, organoleptic and visual characteristics) 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 and data, and supported by expert and consumer 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.

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Identifying Appropriate Delivery Options for Fortified Rice

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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 afforded by rice fortification.
- 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.
- The main challenges identified for a sustainable mandatory rice fortification are: very high initial investment to develop a high-quality fortified kernel industry and implementation of an effective regulatory system.

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. Rice is estimated to be a staple food for over 3.5 billion people, half of the world's population. Its consumption had traditionally been concentrated in Asia but is now increasingly important in Latin America and sub-Saharan Africa.[1] 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 made available 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, the lessons learned from implementing countries and the current status of rice fortification.

> "Fortified rice can reach consumers through three different delivery options"

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.[2] If a food is commonly consumed by all segments of the population, mandatory fortification of that food will result in increased micronutrient intake without requiring behavior change. Governments tend to institute mandatory fortification when the prevalence or risk of

TABLE 1: Status of mandatory rice fortification, by country

Country	Legislation year	Rice source, fortified kernel source, and milling industry	Status
Costa Rica	2001	40% imported; two domestic fortified kernel producers; 11 mills	100% fortified
Nicaragua	2009	80% rice domestically grown; 40+ mills, many small	Not yet being implemented
Panama	2009	40% rice imported; initial plan for government to pay for kernels	Not yet being implemented
Papua New Guinea	2007	All rice imported; fortified with imported kernels or in country of origin	At least 80% fortified
Philippines	2001	13% imported; ~11,000 mills	1%–2% total rice fortified in 2006–2013. Currently <1%
United States	1958	All domestic rice fortified, likely with dusting technology	70% fortified

micronutrient deficiencies are widespread, and when a suitable food vehicle that is consumed by the majority of the population can be effectively fortified.[3] Mandatory fortification requires considerable government will, advocacy and leadership to create the necessary legislation and enforcement system.

Current status of mandatory fortification

Six countries have mandatory rice fortification legislation, but only three – Costa Rica, Papua New Guinea and the United States – are effectively implementing their legislation as the remaining countries have reported challenges and experienced constraints (**Table 1**).[4]

Costa Rica has the most successful mandatory rice fortification program, with 100% of rice fortified. Costa Rica also mandates fortification of other staple foods such as wheat and maize flours, milk and oil, to reach all population segments with all necessary micronutrients. Through this 'fortified food basket' approach, significant declines in iron deficiency anemia[5] and neural tube defect rates[6] have been achieved, but it is not possible to know the attribution to rice fortification alone.

Approximately 80% of rice in Papua New Guinea (PNG) is fortified; implementing rice fortification is logistically facilitated in PNG by the fact that almost all rice is imported by a small number of rice importers rather than domestically grown. However, although rice importers are indeed importing fortified rice, there are indications that some are using dusted rice which has high nutrient losses when washed.

The United States is the third country successfully implementing mandatory rice fortification. 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[7] have mandatory legislation and have effectively leveraged their legislation so that an estimated 70% of the US rice supply is fortified.[8] However, rice is fortified using a dusting technology, as evidenced by mandatory labeling advising consumers to avoid washing rice before cooking.[9]

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. Despite significant efforts by the government, the private sector never started rice fortification on a large scale, primarily due to a fragmented rice milling industry landscape and the low fortification capacity of the thousands of small millers.

Similarly, the governments of Nicaragua and Panama are not actively enforcing their rice fortification legislation.[10] Again, these countries are hampered by the high fragmentation of the rice milling industry and low industry capacity for fortification. In Panama discussions are in progress to update the rice fortification law in order to improve feasibility for the private sector. In Nicaragua there is a recognized need to improve local capacity to monitor and regulate fortified rice. Lacking appropriate monitoring and regulation, efforts have been made to quantify the prevalence of folate deficiency in women of childbearing age, as well as to develop social marketing materials to create consumer demand (similar to a voluntary fortification model). These three countries illustrate the need for appropriate legislation that reflects the feasibility for the private sector to implement rice fortification.

Lessons learned from mandatory fortification

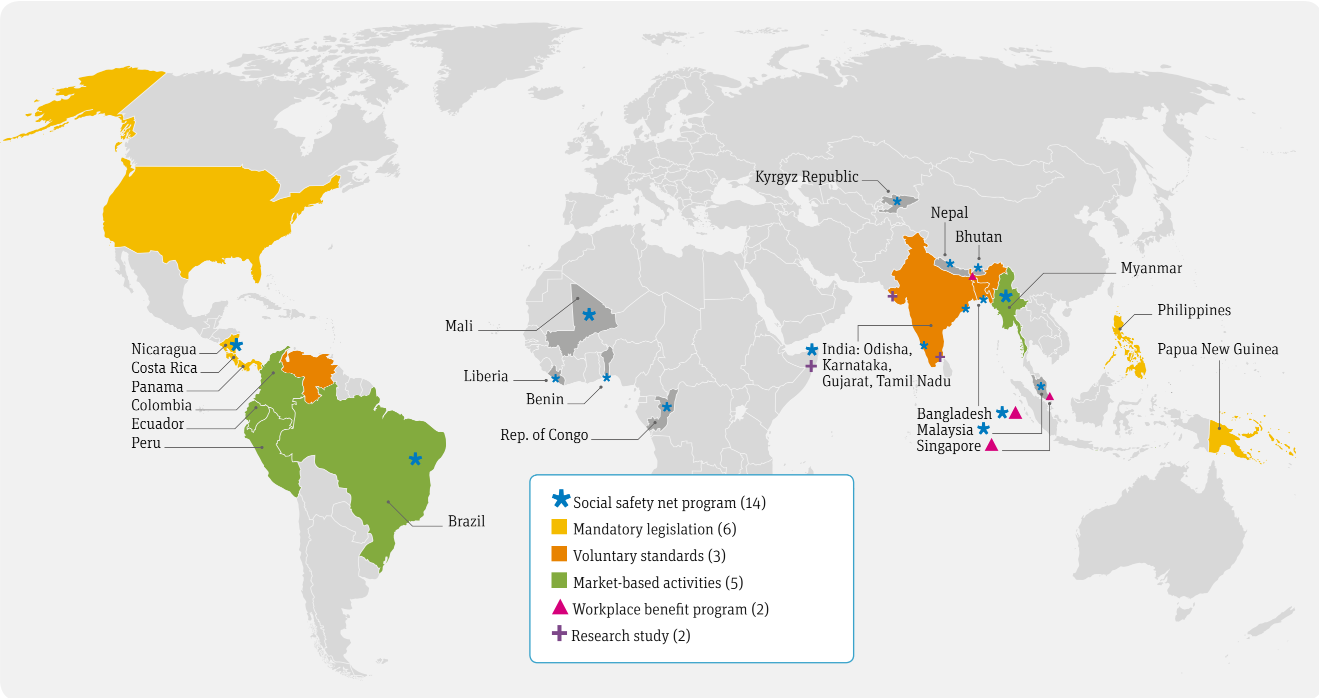
Mandatory fortification provides the greatest opportunity for large-scale, sustainable public health impact

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 that mandatory rice fortification would be an effective and also cost-effective strategy to improve micronutrient intake. Costa Rica is considered the country with the most successful rice fortification program globally, with an estimated 100% of the national supply of rice fortified.[11]

Political will is necessary to establish mandatory fortification

Political will and commitment are key for passing national legislation requiring the addition of specific micronutrients to the

FIGURE 1: Global status of rice fortification programs



Credit: FFI database, updated May 2018

identified food, and for setting national standards. Thereafter, continued political will and government capacity are necessary to resource and implement regulatory monitoring systems for effective enforcement of the legislation and standards.

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. Mandatory rice fortification will be most feasible in countries where there is a consolidated rice milling or rice-importing industry. In countries such as the Philippines, and perhaps a lesser extent, Nicaragua, the fragmented milling structure has been a significant constraint to the implementation of mandatory rice fortification legislation.

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 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 increased cost may be so negligible as to be unnoticed by the average consumer. 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.

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. On the other hand, investing in a domestic fortified kernel production facility is expensive and potentially risky: private companies interested in investing in fortified kernel production will need to be 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 compare the relative costs of domestic fortified kernels versus imported kernels and evaluate the government's political will, manpower and 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 labeling 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 social marketing to encourage people to purchase fortified rice.

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 capture new market share and increase sales. However, due to slow build-up of consumer demand, especially among poorer populations, the potential for going to scale and influencing a population's micronutrient health may be limited. Impact will also be limited as lower socioeconomic groups, who are most in need of fortification, are least likely to purchase fortified brands due to their higher cost. Voluntary approaches to rice fortification have not yet been systematically evaluated to see if a health impact has been achieved.

Status of voluntary fortification

Few countries have voluntarily fortified rice consumed by a significant proportion of the population, although several countries have fortified rice available in the marketplace in a limited capacity. As an example, in Colombia voluntary fortification by a small number of rice millers with a major market share has led to about 35% of the national rice supply being fortified. Unfortunately, Columbian millers use a rice fortification method (spraying) that has unclear nutrient retention after washing and cooking, which could reduce the attendant public health benefit.[12] In Brazil,[13] implementation has not been achieved at large scale (only an estimated 1%–4% of rice is fortified) because rice millers are fragmented and consumer motivation to purchase the premium-priced rice brands is low. In Mali, a Malian rice milling company, Malô, plans to enter the rice fortification industry by broadening its fortified kernel blending operations to include expansion into domestic fortified kernel production. Future plans are to produce a premium fortified rice brand for the local market. See Case Study: Mali on p. 94 and A Day in the Life of Salif Romano Niang on p. 76.

Lessons learned regarding voluntary rice fortification

It is difficult to achieve broad public health impact

Voluntary rice fortification has not achieved high and sustained coverage of the total rice supply in any country where voluntarily fortified rice is known to be available in the marketplace; even in Colombia, where an estimated 35% of the rice is fortified voluntarily by millers,[14] this coverage is relatively low compared to what has been achieved in mandatory fortification settings. If fortified rice is not easily accessible across the entire range of common market channels (for example, bulk sales, local markets), and in particular those most frequently used by the most poor and vulnerable populations, the health benefits will be limited.

Standards are necessary, even in voluntary fortification

Voluntary rice fortification also requires appropriate standards for rice fortification. In Colombia, as there is no fortification standard, millers are able to fortify with nutrients and at levels as they wish, using an untested fortification method. Even in voluntary fortification settings, fortification standards are recommended so that millers have guidance in fortifying at levels that will be consistent and intended to improve public health. Standards can also specify the necessary technological requirements of fortified rice, e.g., nutrient retention levels after washing or cooking. 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.[15] 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. In markets where bulk, unbranded rice is still a common way to purchase rice, voluntarily fortified rice is unlikely to be sold in this way since millers have no ability to market or brand their product. Fortified rice sold only as branded packages thus may lose a group of consumers who purchase rice at their local markets through bulk or unbranded containers.

Increased marketing (i.e., advertising, promotion and packaging) is needed to promote the benefits of the fortification and the premium pricing – but still may not be enough

Contrary to popular belief, marketing and social mobilization campaigns aimed at encouraging consumers to purchase fortified foods, including fortified rice, have failed to result in sustained consumption across a population. Extensive investments in social marketing under a purely voluntary commercial approach in Brazil did not result in increased consumer demand for fortified rice.[16] Voluntarily fortified rice is typically produced to appeal to higher-income consumers and as part of an effort to build a reputation as a premium rice brand.

Delivery Option 3

Fortification of rice distributed through social safety nets

Targeting rice fortification to certain populations that are more likely to be nutritionally vulnerable can be achieved by fortifying rice distributed through social safety nets such as school feeding programs, conditional or unconditional distributions to the poor or to vulnerable groups, and food assistance during emergency situations. Subsidies and vouchers for fortified rice are also a possibility but require that fortified rice be easily available to beneficiaries in their usual marketplaces. 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. Theoretically, experiences in fortifying social safety net rice may also potentially sensitize policymakers and governments to consider mandatory rice fortification – although this has not yet occurred in practice.

Status of fortification of social safety net rice

Several countries in West Africa have government-run programs, supported by partners, which distribute fortified rice as part of a social safety net program.

During 2018, the United States Department of Agriculture's McGovern-Dole Program provided fortified rice in partner-supported school feeding programs in Benin, Liberia and Republic of Congo, as well as in Nicaragua, Kyrgyz Republic and Nepal (2018 volumes not yet confirmed). In 2017, the same program donated approximately 9,000 metric tons across its global programs. In 2016, WFP distributed 15,500 metric tons of fortified rice in Niger, Mauritania and Chad through the United States Agency for International Development's Food for Peace Program.

In Mali, WFP has partnered with Malô to blend imported fortified kernels into locally produced rice to provide fortified rice for WFP's school meals. WFP is using the Malô experience as a logistics pilot to understand how cost-effective this type of model of producing fortified rice through imported kernels domestically blended could be in a West African context as well as to evaluate if it could be replicated elsewhere in WFP's food distribution programs.

Fortified rice is also featured in other social safety nets across Asia, most prominently in school feeding programs across India and government programs in Bangladesh.[18]

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 to those most in need

The school cook preparing fortified rice for the children in Mali

© Jelle Goossens (Rikolto)

Mandatory rice fortification will be most feasible in countries where there is a consolidated rice milling or rice-importing industry. The domestic rice milling industry is growing in Senegal and may present opportunities for rice fortification.

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. Barriers to adding fortified rice to an existing social safety net program include supply chain difficulties in incorporating fortified rice, additional cost to be borne by governments or donors to purchase and blend fortified rice, and the need to ensure adequate sensitization of the recipient population in order to ensure adherence.

A young girl in Mali participating in a WFP program

© Cécilia Aspe

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 most often funded and implemented by the government, often with support from partner organizations. 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 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 faced with a price increase.

Fortification costs may be substantial

Although the fortification manufacturing cost will be a small percentage of the overall program operation expense compared to the costs of procurement and distribution, the initial capital costs and recurring costs may still be considerable. In mandatory fortification programs the cost of fortification is shared by all consumers and possibly millers, whereas in social safety net programs the cost of fortification is often borne by the program funder.

Logistical issues may impede implementation

Although there has been limited experience with using fortified rice in a large-scale social safety program in West Africa to date, social safety net programs in other regions have experienced logistical difficulties such as sourcing rice for distribution, contracting millers to blend and sourcing fortified kernels. There is also an increasing trend in social safety net programs toward cash transfers or vouchers, and there will be logistical challenges to ensure that fortified rice is available for beneficiaries to purchase in these programs. Challenges also exist in the implementation of large-scale social safety net programs themselves, including ensuring adequate management and effective and efficient targeting.

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, general awareness of the importance of fortification is helpful to preemptively address any potential consumer concerns about fortification.

Considerations for choosing the optimal delivery option

With the reliance on rice as a staple food throughout West Africa 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 suffering from 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, it is only possible under certain conditions."

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 (see p. 68 for Tsang et al article on fortification opportunities in Africa) 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. See article on Feasibility and Potential for Rice Fortification in Africa (p. 31).

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.

> "Social safety net programs are an excellent way of reaching vulnerable groups with fortified rice and they provide valuable manufacturing and distribution experience"

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 not achieved high coverage in countries where voluntarily fortified rice is currently available. 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.

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A Day in the Life of Salif Romano Niang

Salif Romano Niang is co-founder and Chief Impact Officer of Malô, a Mali-based social enterprise that creates and sells affordable, culturally appropriate rice-based products that enhance the health of mothers, children and the planet. He explains his vision to turn the brand Supermalô into the 'Uncle Ben's of Africa'.

***Sight and Life* (SAL):** *Salif Romano Niang, you are a citizen of Mali, you were born in Italy and you grew up primarily in Ethiopia. What do these three countries mean to you today?*

Salif Romano Niang (SRN): I was born in Rome, because my parents were living there at the time. My father was a livestock economist at the United Nations Food and Agriculture Organization (FAO) in Rome at the beginning of his career. When my mother was pregnant with me, everyone expected me to be a boy, so I was referred to even before my birth as il bambino romano – 'the Roman baby boy' in Italian. That's why my middle name is Romano.

My father was subsequently transferred to the United Nations Economic Commission for Africa in Addis Ababa. This was at the time of the Ethiopian humanitarian crisis of the mid-1980s. I attended the International Community School of Addis Ababa, which is why I speak English with an American accent – something about me that often surprises people when they meet me for the first time. Ethiopia was synonymous with famine when I was growing up, and I had firsthand encounters with people dying of malnutrition – something that made a deep impact on me.

Salif Romano Niang (left) former US President Bill Clinton following Malô's Commitment to Action in New York City, September 2013

Faso Jigi's storage warehouses. Malô's rice fortification line is installed in the building on the left and unfortified rice is stored in the building on the right. (Ségou, Mali)

Salif Romano Niang with his father, giving a tour of the fortified rice storage space in Malô's Ségou facility to the board of Faso Jigi, Malô's partner and host in Ségou

Malô's rice cleaning, grading and fortification line (Ségou, Mali)

> "Ethiopia was synonymous with famine when I was growing up, and I had firsthand encounters with people dying of malnutrition"

As for Mali, the country from which my family originates, my parents were always very keen for my siblings and me to return there during the vacations, and so I would spend several months of every year living a normal life in the local villages among my extended family.

SAL: *In 2002 you relocated to the United States, where you studied over the course of the following 11 years. In what ways have your academic studies influenced your current thinking? And what is the influence on the USA on your life and worldview today?*

SRN: I attended Purdue University in Indiana to study agricultural economics at my father's insistence: he had won a USAID scholarship to pursue graduate studies there himself. He wanted all his children to follow in his footsteps but I was the only one to study agriculture. Purdue was quite a culture shock for me at the outset because I had grown up in a very international environment on account of my family background and schooling and I had a very international outlook. My fellow students at Purdue were all drawn from the local population and I initially struggled a little with the lack of diversity.

I also struggled with agricultural economics, a subject about which I knew nothing. I had always taken a keen interest in politics and current affairs and so, after a while, I switched to international relations (with an emphasis in international law). That was a subject I really enjoyed. Agriculture plays a central role in feeding people, and studying it from this perspective fascinated me. I'm especially interested in how demography, and large youth cohorts in particular, influence national power, conflict risk, governance and economic development.

So studying at Purdue turned out to be a great experience for me in the end, allowing me to explore what really interested me and also to make many excellent contacts. I received a Bachelor's in Political Science, French and Economics, and a Master's in International Relations and Comparative Politics.

SAL: *You embarked on a PhD but temporarily suspended your studies in 2011 to set up Malô. What does Malô mean, by the way?*

SRN: It means 'rice' in Bambara, the most widely spoken of the many languages of Mali and West Africa.

Salif (right) and his brother Mohamed Ali Niang with Bill Gates Sr after winning the Judges' Choice Award, March 2010

SAL: *And what was the inspiration behind the creation of Malô?*

SRN: My father's work with the United Nations put him at the forefront of food security in Africa when he was younger and this was a subject that we would often discuss. I observed the world food crisis of 2007/2008 with keen interest, as food price spikes triggered food insecurity, then food riots, then wider unrest, and eventually political violence in some countries. The World Bank estimated at the time that 100 million people fell back into poverty, given rice's key position in total household budget expenditure. In Mali itself, poor storage and inefficient milling were leading to wastage of a large proportion of locally grown rice and, by 2012, 81% of children under five in the country were anemic.

My brother Mohamed Ali Niang and I founded Malô to help address this situation. We conceived it as a social enterprise. We searched online for studies by USAID, picked the brains of professors, emailed our business model and financial projections to seasoned entrepreneurs for them to deconstruct, and video-chatted with technology providers in Argentina and China to put together a business plan that was to eventually win over US$130,000 in prize money and awards. With these funds, we returned to Mali in 2011 to conduct a pilot study that culminated in the marketing of locally produced fortified rice in Africa for the first time, selling an initial volume of 10 tons even though the product was completely new to local markets. Although I had initially been granted a sabbatical from my PhD studies in order to set up Malô, I eventually found it impossible to return to them. Malô required too much of my attention.

SAL: *What challenges have you had to overcome since first establishing Malô, and what challenges still exist?*

SRN: Funding itself was not an obstacle at the beginning because we had the prize money to get the business off the ground. We also received external funding from patient capital investors, who have supported us financially at critical times over the past seven years: Halloran Philanthropies (a family foundation based in Pennsylvania), Suzanne Salomon (an angel investor from New York), Open Road Alliance, Oikocredit (a Dutch nonprofit organization), and LuxDev. The coup of 2012 slowed our progress enormously, however, making it time-consuming to obtain the necessary government/administrative approvals for our activities and impossible to access further external funding. Our business plan had to be put on hold for a while. It was clear to us that we were going to lose either a lot of money or a lot of time.

Fortunately, however, my brother Mohamed and I were in the position of not having to support our parents financially, and the family had some real estate, so we were able to use the time to refine our plan and make maximum use of the seed funding we had been given. In retrospect, I think this actually helped us avoid many mistakes that we inevitably would have made if we had launched Malô according to our original timescale.

SAL: *Malô produces the fortified rice Supermalô. You have gone on record as wanting to develop Supermalô into 'the Uncle Ben's of Africa'. What does this ambition mean, in concrete terms? And what would achieving it mean for Africa?*

SRN: Uncle Ben's parboiled rice was first launched in the US in 1943 and is a global brand today. The technique of parboiling rice was developed in the early 20th century as a means of retaining more of the nutrients in the rice grains. When I speak of turning Supermalô into 'the Uncle Ben's of Africa', I am not thinking of personal commercial gain – my brother and I have made no money ourselves from Malô; that is not the object of the enterprise. Rather, I am envisioning an environmentally and socially conscious consumer brand that brings high-quality, safe, affordable and nutritious rice to the population of Africa – a brand that everyone knows and trusts.

"I am envisioning an environmentally and socially conscious consumer brand that brings high-quality, safe, affordable and nutritious rice to the population of Africa"

Salif meeting with members of a farmers' cooperative in his home village of Kéniéba, Mali, January 2015

SAL: *The fortification of rice is technically more challenging than the fortification of certain other staple foods. What have you and your colleagues in Malô learned from rice fortification programs in other parts of the world?*

SRN: Yes, staples such as flour, salt and sugar have been fortified for a long time but the fortification of rice presents greater technical challenges. We now have the technology to overcome these difficulties but we are still challenged by the dysfunctionality of the milling sector in countries such as Mali, where most milling is done using small village machines pulled by donkey carts. We're currently working with equipment donated by GAIN (the Global Alliance for Improved Nutrition) to enable us producing fortified rice kernels in Mali. Between 90 and 95 percent of the content of fortified kernels is rice flour, which is a by-product of milling, and the vitamins for fortification are not expensive, given the low dosage rates. It's important to position fortified rice not as a therapeutic food for people who are sick but as a healthy food for everyone.

Samples of unfortified rice, fortified kernels and fortified rice collected by a technician from the *Laboratoire Nationale de la Santé* (National Health Laboratory)

"It is important to position fortified rice not as a therapeutic food for people who are sick but as a healthy food for everyone"

SAL: *What are your hopes for Africa, Salif, and what initiatives beside rice fortification hold promise for the continent?*

SRN: The overall direction of Africa's development is positive but I feel that our leaders need to do more to keep up with the pace of change. My hope is that the next generation of Africans will be the most educated ever. Africa is in many ways still virgin territory in terms of business creation and we have the opportunity to create new businesses from scratch here that have the right values.

SAL: *Do you have a favorite recipe for a rice-based meal? Could you share it with our readers?*

SRN: I've lived in lots of countries and I like many dishes, but my personal favorite is jollof rice (zamé in Bambara). It's an African comfort food comprising fried rice with vegetables and seafood, similar to paella in Spain or jambalaya in Louisiana. I'm glad to see that people are starting now to pay more attention to cooking as a component of food security and nutrition. Africa needs examples of healthy, easy-to-prepare dishes.

SAL: *Your work is multifaceted and international in nature. Do you still find time for hobbies?*

SRN: My great love is soccer. I don't play as much now as I used to, but I've been an FC Barcelona supporter since 1994 and I try to watch them as often as I can. I'm also very interested in music. I don't play an instrument myself, but I have many friends in the music industry in Mali. The local musical talent in Mali is incredible and I'm keen to support it. Food and fun are essential to life!

SAL: *Where do you feel most at home today?*

SRN: I'm very happy in Mali right now. I like it very much – especially the town of Ségou, to which I moved a year ago. I'm looking to put down roots here. That said, I could imagine living abroad again at some point in my life, perhaps in Rome or Barcelona.

A popular rice dish (zamé) made with rice fortified by Malô

© Malô

© The US White House

Salif (left) and his brother Mohamed Ali Niang with US President Obama during Feed the Future Agricultural Technology Marketplace in Dakar, Senegal, July 2013

SAL: *Is there a figure in your life who has been a particular inspiration to you*?

SRN: My mother and father have always been a great source of inspiration to me, and they instilled in me a deep sense of the importance of serving the community. Barack Obama, whom I was fortunate enough to meet in Dakar in 2013, is also someone I greatly admire. He's immensely intelligent and at the same time very humble and approachable. Meeting him in person, I never would have dreamt that he was President of the United States.

SAL: *Any other message for our readers?*

SRN: I'd like to say that I'm optimistic for Malô, but I'm also optimistic for Mali and for Africa in general. I've met some amazing people in the course of the past eight years – people who have been generous with their time, their resources and their advice, and who have helped us as entrepreneurs to create the conditions for other entrepreneurs to succeed as well. We need to get more people into the food sector in Africa and, to do that, the economic opportunities have to be available.

SAL: *Thank you, Salif, and the best of luck with everything you do!*

SRN: Thank you.

Salif Romano Niang was interviewed by Jonathan Steffen

Addressing Myths and Misconceptions about Rice Fortification

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Disclaimer:
The findings and conclusions of this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Key Messages

- Rice fortification is safe.
- Rice fortification cannot eliminate all micronutrient deficiencies; it complements other strategies such as biofortification and dietary diversification. Supplements will continue to be important for the most vulnerable groups such as pregnant and lactating women and preschool children.
- Rice fortification benefits consumers with access to commercial markets where fortified rice is sold as well as beneficiaries of social safety net programs that include fortified rice. In both cases, this can include rural and urban populations.
- When fortified with multiple micronutrients, fortified rice is more micronutrient-rich than brown, parboiled or non-fortified white rice.
- Any variety or type of rice can be fortified.
- Current technologies can produce fortified rice that tastes, smells and looks the same as non-fortified rice.

Introduction

This paper addresses concerns, myths and misconceptions in West Africa about the benefits and safety of rice fortification by presenting information from the global experience.

Is rice fortification safe?

The type and levels of micronutrients added to rice are calculated so that the lowest possible proportion of consumers **(1)** have unacceptably low levels of nutrient intakes and **(2)**

Jollof is a common rice dish throughout West Africa where nations debate which serves the best version of this dish.

The Gatsibo Rice Mill in Rwanda buys rice from local farmers and processes it for local consumption

exceed the tolerable upper intake level of any nutrient.[1] The recommended daily intake for individuals varies based on a person's age and gender.[1] The highest level of intake that is likely to pose no risk of adverse effects is considered the tolerable upper intake level.[1] Rice fortification standards also consider the micronutrients consumed and the daily or regular quantity of rice consumed by the target population.[1] In other words, fortified rice fills the micronutrient gap, without promoting excess intake.

Specific population groups have higher micronutrient needs than others.[1] For example, pregnant women are recommended to take iron/folate or multiple micronutrient supplements to meet their micronutrient requirements. Young children may also take vitamin A or other micronutrient supplements. Providing supplements to these vulnerable groups remains safe and may need to continue even when they are consuming fortified foods because their micronutrient requirements are much higher than those of the average population.

Is fortified rice made with plastic or non-edible ingredients?

In recent years, a rumor has spread through West Africa that some rice being sold in local markets was made of plastic.[2] To date no cases of plastic rice have been identified despite investigations and analyses of rice available for sale.[3] With fortified rice, all ingredients are edible.

Fortified rice is produced using one of two technologies (see Milani et al, p. 48 of this supplement):

1. Coating covers the surface of the rice with a layer of vitamins and minerals.
2. Extrusion involves production of fortified kernels made from water, rice flour and a mix of vitamins and minerals.

In both techniques, the non-rice-based components are the edible vitamins and minerals needed to impact the nutritional status of consumers. Additionally, with coating, edible gums and waxes are used to make the nutrients adhere to the rice.

Is rice fortification necessary, alongside other programs, such as dietary diversity?

Currently multiple interventions contribute to reducing malnutrition in West African countries, including vitamin and mineral supplementation, food fortification, promotion of dietary diversification, homestead food production, biofortification and public health measures such as immunizations and malaria and parasite control.[4] Rice fortification is meant to complement, not replace, these existing programs to improve the nutritional status of the target population. Fortification of staple foods, including rice fortification, is one of the most important, safe, cost-effective, scalable and evidence-based tools to help address widespread micronutrient deficiency.[5] It has also been repeatedly highlighted as one of the best development returns on investment.[6] WFP recently conducted Fill the Nutrient Gap (FNG) analyses in Niger.[7] FNG combines a review of secondary data information with linear programming analysis, using the Cost of the Diet software developed by Save the Children UK.

Fortification, when combined with other nutrition interventions, contributes to reducing costs to meet nutrient requirements for the household as well as for specific target groups, in particular pregnant and lactating women and adolescent girls.

Will fortified rice benefit rural consumers?

Mass fortification is the "addition of micronutrients to foods commonly consumed by the general public."[1] Mass-fortified food reaches consumers who have access to commercial markets. This is one of its benefits: new distribution channels do not need to be created because they already exist. In different countries, different regions will have varying access to commercial markets and hence to fortified rice. For example, in Guinea-Bissau, because rural farmers trade locally grown cashews for imported rice, fortified rice could have greater reach in rural Guinea-Bissau than in rural Nigeria, where local farmers are less likely to buy rice in the commercial marketplace.[8] In comparison, the rural reach of fortified rice in social safety net programs will depend on the intended target population for that program – if a school feeding program targets rural school children, then rural children will benefit. On the other hand, if urban poor are the targeted recipients of a food distribution program, then rural coverage will be limited. Depending on which distribution mode of fortified rice is chosen, a varying proportion of rural consumers may benefit.

What is the difference between fortified and biofortified rice?

Rice fortification and biofortification are different ways 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.[9]

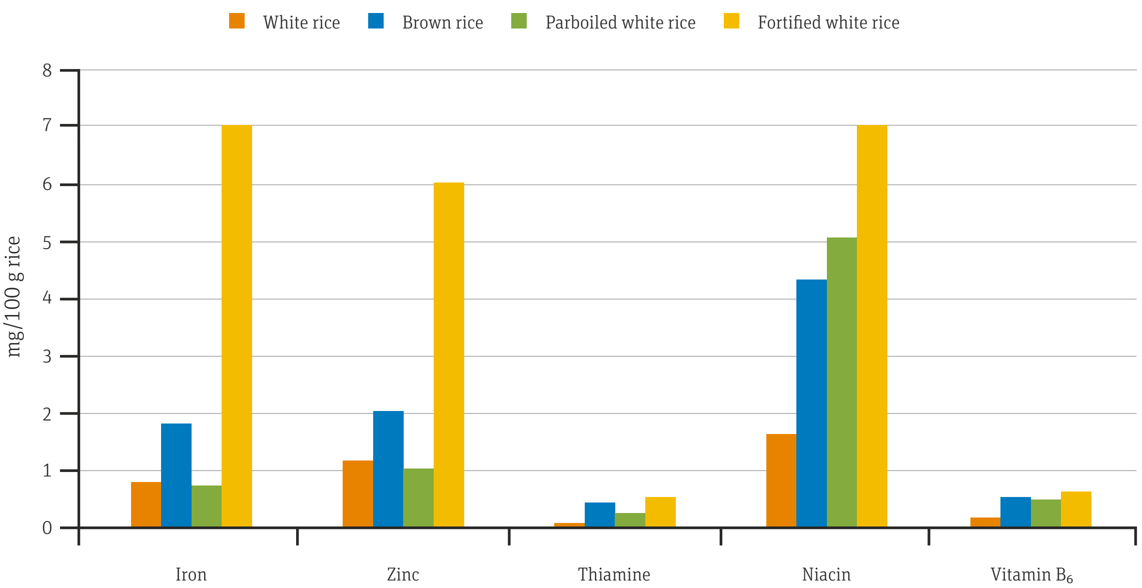
In rice fortification, micronutrients are added after the rice has been harvested. Many nutrients such as vitamins B_1 (thiamine), B_3 (niacin), B_6 (pyridoxine), B_9 (folate), B_{12} (cobalamin), A (retinol), D (cholecalciferol), E (tocopherol), iron, zinc and selenium can be added without changing the appearance of the rice. The number and levels of nutrients that are added to rice can be much higher with fortification than with biofortification. For additional information on rice fortification nutrients and levels, please refer to the contributions by de Pee et al (p. 63), Milani et al (p. 48), and Rudert et al (p. 87) in this supplement.

Biofortification increases the micronutrient content before the crop is harvested. The process is through conventional plant breeding or genetic modification (GM). An example of GM biofortification is Golden Rice, which expresses β-carotene.[10] 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.

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

White rice is widely consumed and, when fortified, it can have a significantly higher micronutrient content than non-fortified rice, including brown or parboiled rice. Therefore, there is a

FIGURE 1: Profile of select micronutrients in white rice, brown rice, parboiled white rice, and fortified white rice[11]



greater potential to improve micronutrient health by fortifying white rice than from increasing consumption of brown or parboiled rice. If brown or parboiled rice is the preferred rice, these can also be fortified.

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

Figure 1 shows the micronutrient content (iron, zinc, thiamine, niacin and vitamin B_6) for non-fortified rice (white, brown, and parboiled) and fortified white rice.[11] The content of folate and vitamins A and B_{12} are not shown because they are absent or negligible in all types of rice except fortified rice. The data demonstrate 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 B_{12}.

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 rice were to be promoted. While there is little data on brown rice consumption in West Africa countries, the 2009 US National Health and Nutrition Examination Survey 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).[12]

Local customs for preparing rice, such as sorting and rinsing, must be considered when choosing the best technology for rice fortification

Can any variety of rice be fortified?

With coating and extrusion, all varieties of rice can be fortified. For more information on rice fortification technology, please refer to the contribution by Milani et al (p. 48).

Can broken rice be fortified?

Yes, broken rice can easily be fortified. The same technologies used to fortify non-broken rice (e.g., extrusion, coating) can also be used to create fortified kernels to blend with broken rice.

Is fortified rice acceptable to consumers?

The acceptability of fortified rice depends on the quality of the fortification technology, the type and levels of nutrients added,

TABLE 1: Summary of sensory studies comparing fortified rice developed through extrusion or coating technology, with unfortified rice[13]

Study	Sensory evaluation outcome(s)
Shrestha 2003[14] (coated, folic acid)	No difference between fortified and unfortified rice.
Moretti 2005[15] (extruded, iron)	Tested multiple kinds of micronized iron compounds. No difference between fortified and unfortified rice.
Beinner 2010[19] (extruded, iron)	No difference between fortified and unfortified rice.
Radhika 2011[20] (extruded, iron)	No difference between fortified and unfortified rice.
Khan Van 2014[16] (extruded, multivitamin)	*Able to identify fortified rice but were neutral or favored fortified rice more than unfortified rice.*
Hussain 2014[18] (extruded, multivitamin)	*Able to identify fortified rice but had similar preference for fortified and unfortified rice.*
Wieringa 2016[17] (coated, extruded, multivitamin)	Children: No difference between fortified and unfortified rice.
	Women: Preferred a coated fortified rice; liked the other fortified rice the same as unfortified rice.

and consumer preferences. All rice fortification technologies aim to make fortified rice taste, smell and look the same as non-fortified rice. We reviewed studies that assessed the sensory qualities of extruded or coated fortified rice compared with non-fortified rice.[13] In **Table 1**, the first column lists the study and in parentheses the fortification technology used and the nutrients added to the rice. For example, for the second row, Shrestha and colleagues tested coated rice fortified with folic acid only.[14] In the case of the Moretti 2005 study, multiple kinds of micronized iron compounds were tested.[15] For the Khan Van 2014[16] and Wieringa 2016[17] studies, fortified rice made with multiple technologies was tested. The second column has the main results observed. Text not in italics represents studies where the participants did not note any sensory differences between the fortified and unfortified rice. The first two studies with italicized text had similar findings: participants were able to identify fortified rice but they had a similar preference for fortified and unfortified rice, or favored the fortified rice (Khan Van 2014,[16] Hussain 2014[18]). The last study with italicized text had two key findings: women preferred a specific manufacturer's coated fortified rice compared to non-fortified rice but liked the rest of the extruded and coated fortified rice samples the same as non-fortified rice (Wieringa 2016[17]). Taken together, all of these studies suggest that consumers will not reject fortified rice based on sensory qualities.

Conclusion

Fortified rice is safe and acceptable to consumers. Fortification levels add micronutrients without causing excessive intake. Fortified rice is acceptable to consumers as virtually any type of rice can be fortified and, if properly produced, can taste, smell and look the same as non-fortified rice. Among consumers who predominantly eat white 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. Rice fortification benefits consumers who have access to commercial markets where fortified rice is sold and those who are beneficiaries of social safety net programs; in both cases, rural dwellers can benefit from rice fortification. 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 and children, may require additional interventions to meet their micronutrient needs. The broader strategy can include complementary interventions such as biofortification and dietary diversification.

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Women sell rice in Benin, where three large importers comprise 74% of the rice market

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Linking Rice Fortification Opportunities with Nutrition Objectives

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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 World Health Organization Guideline: *Fortification of Rice with Vitamins and Minerals as a Public Health Strategy*[1] and the contributions of de Pee et al on standards and specifications for fortified rice (p. 63).

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:

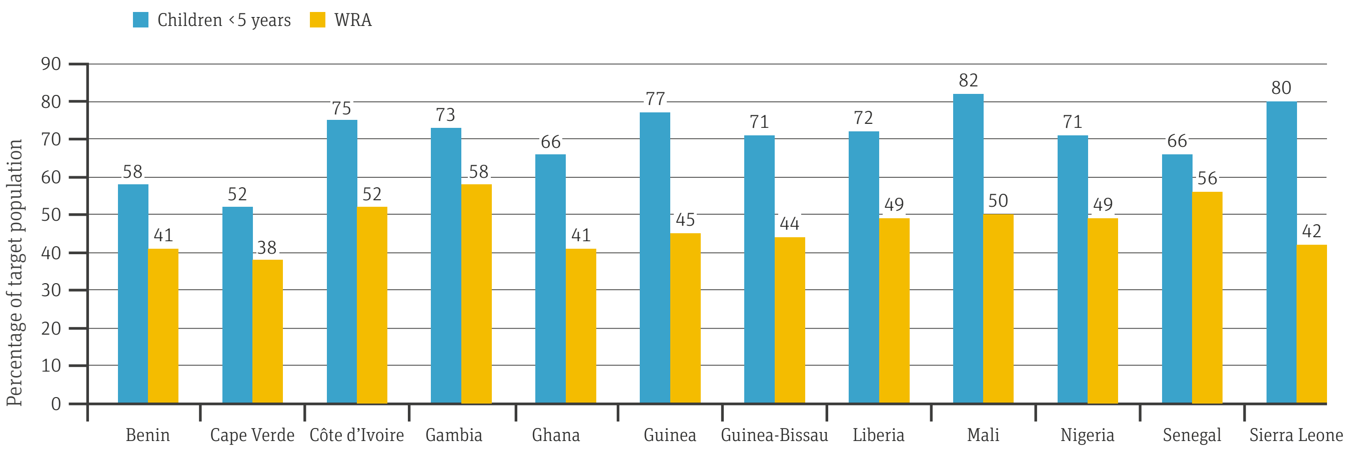
1. Micronutrient deficiency surveys using biochemical data
2. Dietary intake of micronutrients, usually with 24-hour recall surveys
3. Proxy indicators, such as prevalence of anemia, stunting, neural tube defects, dietary diversity, infant and young child feeding practices, food security and sanitation

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. 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.[2] 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 B_{12}, 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 (Hidden Hunger Map, p. 49).

Micronutrient deficiency surveys can estimate a population's micronutrient status using biomarkers such as plasma

FIGURE 1: Prevalence of anemia among children under 5 years of age and women of reproductive age (WRA) in 12 West African countries consuming over 75g/capita/day of rice



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. Although micronutrient deficiencies primarily affect the poorest and rural populations, other socio-economic strata and urban populations may also be affected.

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.

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.

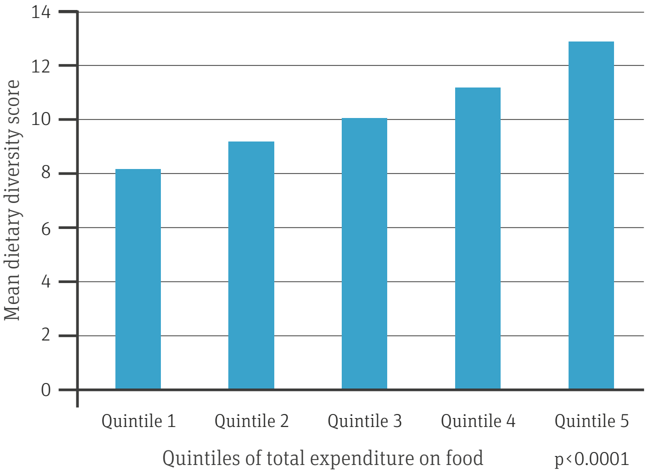
Anemia, commonly used as a proxy indicator for iron deficiency, has multiple causes beyond inadequate iron or other micronutrient intake (e.g., vitamin A, folic acid, vitamin B_{12}). Anemia is most prevalent in children under five, pregnant women and women of reproductive age. Although there is significant variation by country, it is estimated that 25% and 37% of anemia is associated with iron deficiency in preschool children and women of reproductive age, respectively.[3] 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 12 West Africa countries where average rice consumption per day is over 75 g.

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[4] 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.[5] The disparities in stunting prevalence often mirror disparities in micronutrient status and household income levels.

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, preformed vitamin A, vitamin B_{12}, riboflavin, calcium, phosphorus and zinc.[6] Vulnerable groups in populations with a low intake of

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



Adapted from[8]

animal-source foods are more likely to have deficiencies in some or all of these nutrients.[6] 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 antinutritional factors that are present in plant-source foods (pulses, grains, and legumes). Antinutrients, 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.[6] Plant-based foods are often a good source of vitamin B_6, niacin and thiamine. However, polishing rice markedly reduces its micronutrient content.[7]

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.[9] 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 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.

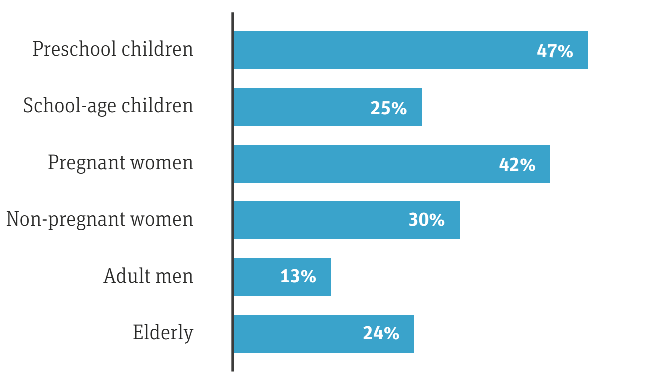
Assessing the burden of micronutrient deficiencies

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.

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 socio-economic groups lack diversity and are primarily based on cereals, roots and tubers, with limited animal-

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



WHO 2008: Worldwide prevalence of anemia

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

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 on standards and specifications for fortified rice (p. 63).

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 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.

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 micronutrient 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 Tsang et al (Identifying Appropriate Delivery Options for Fortified Rice, p. 68).

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.

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

	Low income	High income	Rural	
Voluntary	low	high	low	high
Mandatory	high	high	high	high
Social safety nets	high	low	high	high

Linking rice fortification with nutrition objectives requires the identification of groups that 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.

This article is an updated version of the article that originally appeared in the *Sight and Life*–WFP supplement Scaling Up Rice Fortification in Asia: **issuu.com/sight_and_life/docs/sal_wfp_suppl_08f4522713853b**

It has been brought up to date by the editors on the present supplement. [Ed.]

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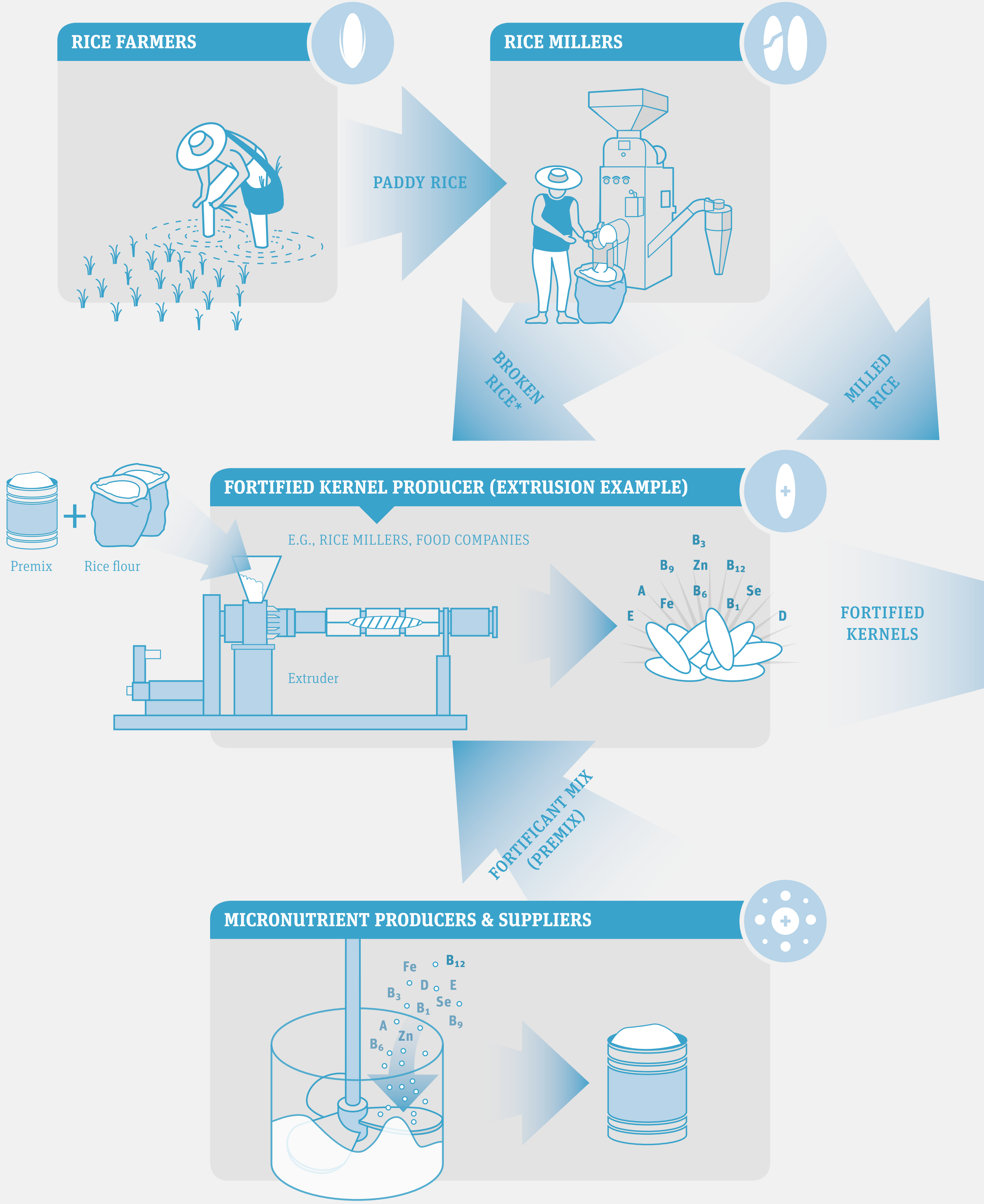
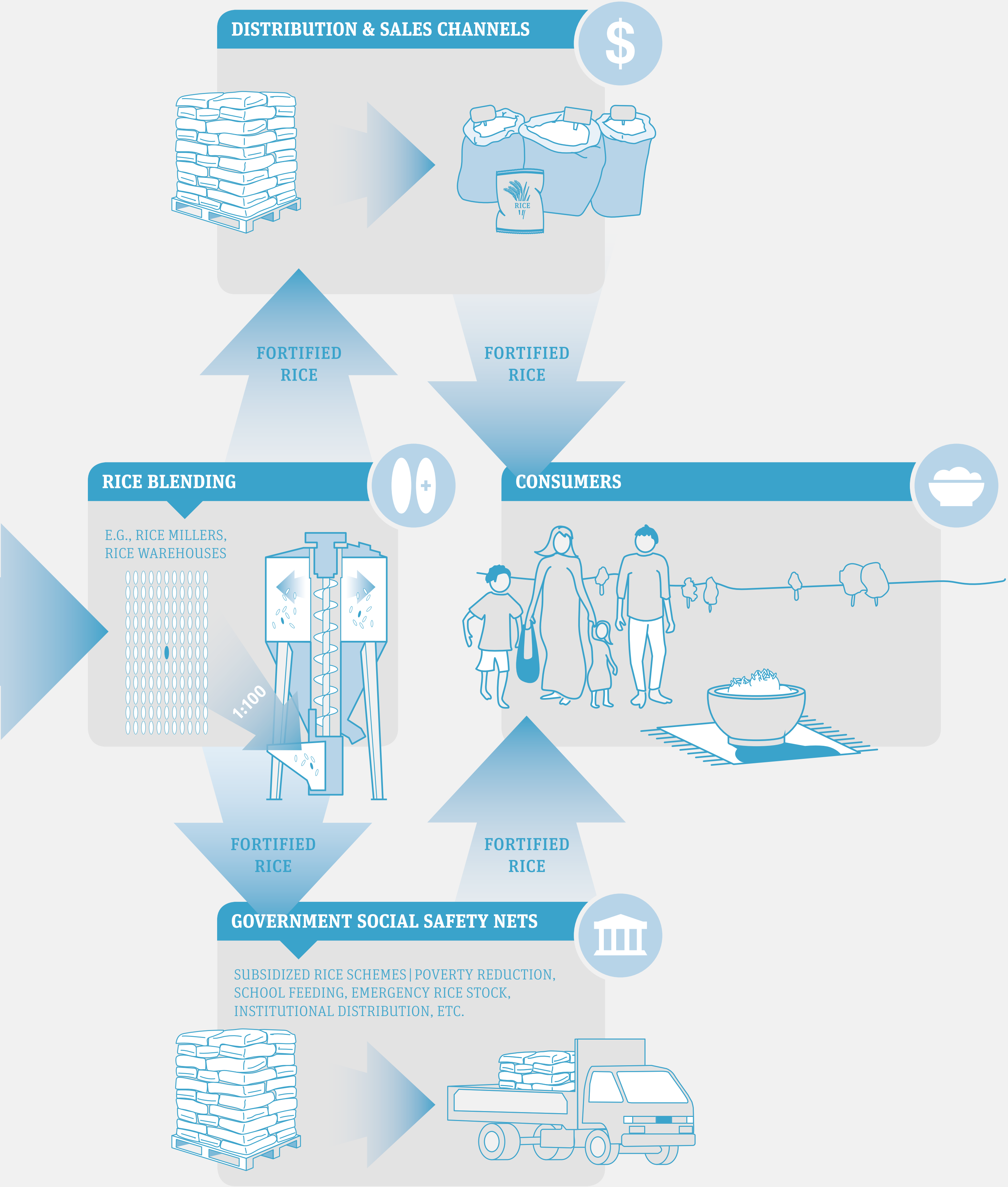
FORTIFIED RICE SUPPLY CHAIN



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



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 micronutrients (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).

Mali Case Study: Generating Evidence for New Operative Model

A tangible approach to rice fortification

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Key Messages

- After one year of program implementation, the project found that it is technically possible to fortify rice in Africa using imported fortified kernels (FK) and blending them with local milled rice.
- Once cooked, the fortified rice mimicked local rice and was accepted by all beneficiaries.
- The additional estimated cost per school year of fortifying rice was evaluated at around US$0.94 per beneficiary, while the project opened new avenues to explore for optimization and further reduction of cost.
- The cost of fortification represented a 5% increase compared to cleaned and calibrated local non-fortified rice.
- Operating fortification of rice is a cross-functional exercise that requires collaboration with and between government entities, the private sector and civil society, both at the national as well as the international level.
- Coordination and ownership of the project are critical factors to ensure adequate follow-up on activities, diffusion of information and communication across teams.

Introduction

Today, the technology is available for large-scale rice fortification that is safe and looks, tastes and can be prepared the same way as non-fortified rice.[1] Rice is fortified in a two-step process: production of fortified kernels (FK) and blending of FK with non-fortified rice.[2] While the technology has been developed, evidence established and consumer acceptability proven, rice fortification programs have not been significantly scaled to determine optimal business models and costs.

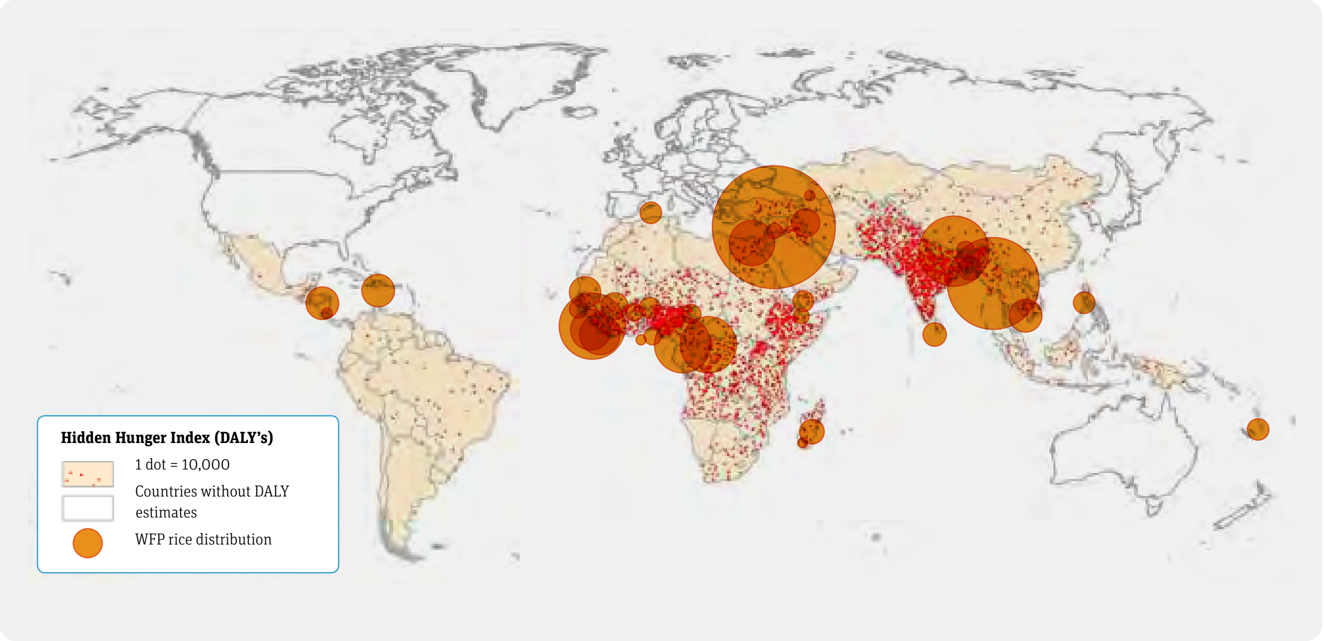
A number of barriers are preventing global scaling of rice fortification including lack of operational experience with public and private sector distribution, missing buy-in from governments and donors, and local complexity due to fragmented value chains and regional policies on rice.[3]

Yet, where rice is a staple food and micronutrient deficiencies (MNDs) 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.

As illustrated in **Figure 1**, today, many of the regions affected by MNDs already receive rice through food assistance programs. Out of 330,000 MT of rice distributed by WFP in 2017, about 11,000 MT (3%) was fortified, representing a modest increase from 2% in 2016. With its global reach and organizational expertise, WFP is well positioned to catalyze the global adoption of rice fortification through market adoption and safety net programs.

In West Africa, rice consumption is increasing in urban areas, reflecting shifts in demographic and dietary patterns. More

FIGURE 1: Total population-unadjusted life years (DALYs) attributed to micronutrient deficiencies in 136 countries and WFP rice distributions



Source: DALY data[4]

and more countries have invested in increasing local production of rice since the 2008–2009 food crisis. Demand in the region continues to grow while at the same time micronutrient deficiencies in West Africa are some of the highest in the world. West Africa offers a good setting to pilot the introduction of fortified rice within WFP's food basket.

To date, locally produced FK are not available on the market in West Africa, and implementing fortification of rice in the region means that FK have to be imported from overseas and blended with non-fortified rice – either locally produced or imported. To test the operational feasibility of such a business model, a project was designed to carry out rice fortification in real conditions by fortifying an initial quantity of rice for WFP distributions in Mali in order to provide lessons and generate relevant evidence to reduce operational and financial barriers for scale-up.

Project description

The Mali rice fortification project, a project awarded by WFP's Innovation Accelerator, was designed to test a program-entry scenario for fortified rice in a large-scale WFP operation. For the first time in West Africa a WFP program distributed fortified rice through school canteens for an entire school year, thereby generating learning and demonstrating to government and the private sector that in-country fortification of locally grown rice fortified with imported FK could be feasible and cost-effective.

Given the absence of local production of FK in Mali, the pilot set out to test whether blending of imported FK with locally grown rice could work as a feasible business model, improving cost-efficiency and reducing a country's need to consider imports of nutritious foods. The objectives of the project were to

1) **implement a new operative market model:** imported FK and local blending of rice;
2) **generate cost transparency** for program set-up and scaling; and
3) **develop a regional scaling model** in West Africa.

The pilot has been monitored, evaluated and documented in terms of operational aspects, key financial performance indicators and acceptability of fortified rice.

In December 2016, a tender was issued by the WFP Regional Bureau in Bangkok, Thailand – the office responsible for rice and FK procurement – for 15 MT of FK (**Figure 2**). The specifications for fortified rice include eight micronutrients: vitamins A, B_1, B_3, B_6, B_{12}, folic acid, iron and zinc. Three offers were received and a supplier in Thailand was selected who produced and delivered the order in two consignments: 14,650 kg by sea and 350 kg by air. Minor quality issues were observed for the 350 kg batch which, based on the information gathered from the supplier, was too small to ensure its homogeneity.

School cook preparing fortified rice for school lunchtime meal, Koulikoro, Mali, January 2018

In total, the FK procurement process took two and a half months from production to delivery meaning that, upon arrival, 80% of the 12 months FK recommended shelf life remained, with clear lessons learned for optimizing the overall import process in the future (**Figure 3**).

Clearance of the FK was delayed due to miscommunication and a lack of experience in clearing this new commodity. FK were a new commodity, as they had not been imported by WFP before in Mali, and it was not clear if they should be considered as a food product. As a result, the project faced delays in the pre-clearance process and in obtaining the necessary official permissions required to import the FK into Mali and obtaining approval for integrating them into school meals.

Selecting the right partner to operate the fortification step was the cornerstone of the project's success (**Figure 4**). A Malian social enterprise, Malô, was selected to operate this step and specifically to process, sort and blend non-fortified rice procured from farmers' cooperatives and traders in the Ségou region (Faso Jigi, ARPASO, Ely Diarra and the Office des Produits Agricoles du Mali) with imported FK. The non-fortified rice that was purchased was the most prized local variety, Gambiaka, which is grown mainly in Ségou and has limited supply nationally due to strong demand. From a financial perspective, this decision meant that good-quality Gambiaka was more expensive to procure than other locally available varieties of rice, which increased the purchase cost of non-fortified rice and the overall cost of the project.

As a new item in the distributed food basket, fortified rice not only needed to mimic non-fortified rice to ensure acceptance by children but it also required that sensitization of the school meal management committees, cooks, and teachers be

FIGURE 2: Sourcing FK through competitive bidding

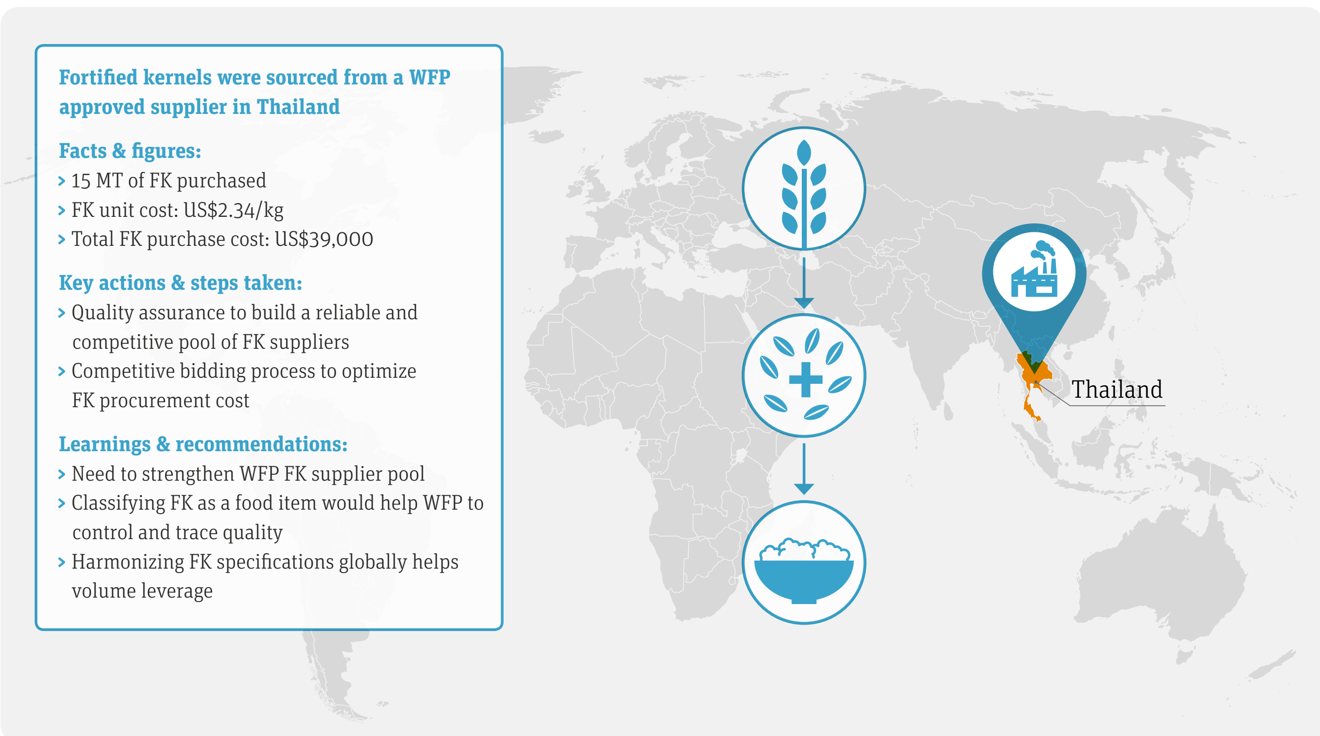


FIGURE 3: Importing FK into Mali

FRK were imported and cleared from customs via Lomé, Togo

Facts & figures:
- Total import lead time: 79 days
- Shelf life left upon arrival: 80%

Key actions & steps taken:
- Obtaining government approvals for FK import
- Clearance of goods
- Inland transportation

Learnings & recommendations:
- Pre-clearance & approval processes with local authorities should start when placing the purchase request
- Documents required for for clearance should be obtained prior to shipment arrival

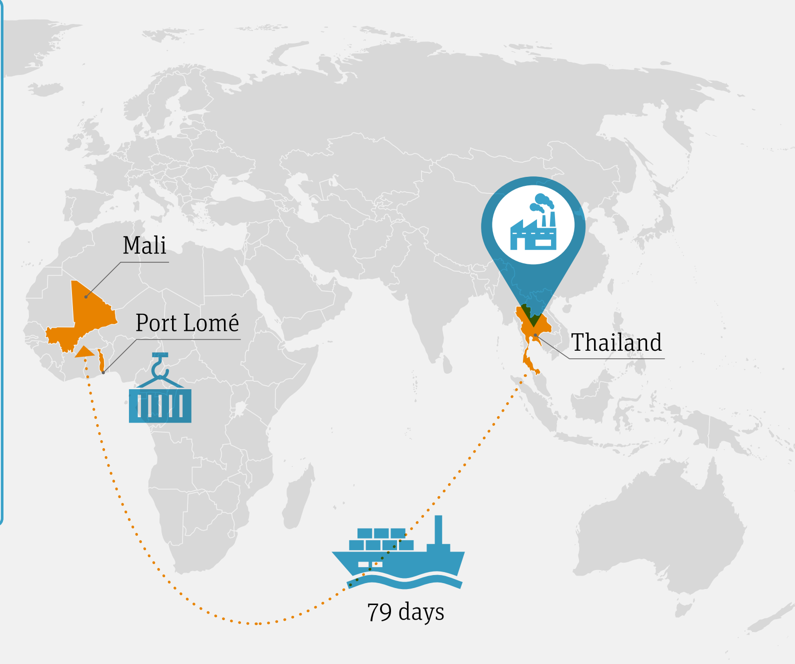


FIGURE 4: Blending FK with local rice

In Mali, non-fortified rice was procured from cooperatives and blended/fortified in a central warehouse in Ségou

Facts & figures:
- 1,485 MT of non-fortified rice procured
- Non-fortified rice cost: US$530/MT
- Fortification cost: US$32/MT
- Fortified rice cost: +5%

Key actions & steps taken:
- Purchase, processing, cleaning & sorting of non-fortified rice procured locally
- Fortification/blending of FK and non-fortified rice & packing

Learnings & recommendations:
- Pre-financing raw materials (FK + non-fortified rice) represents the biggest financial risk for the fortification partner
- Securing quality non-fortified rice at harvest time is key to minimizing sourcing costs
- Using abundantly available local varieties of rice should be preferred over prized varieties
- Strengthening quality control of locally procured rice is necessary to minimize losses

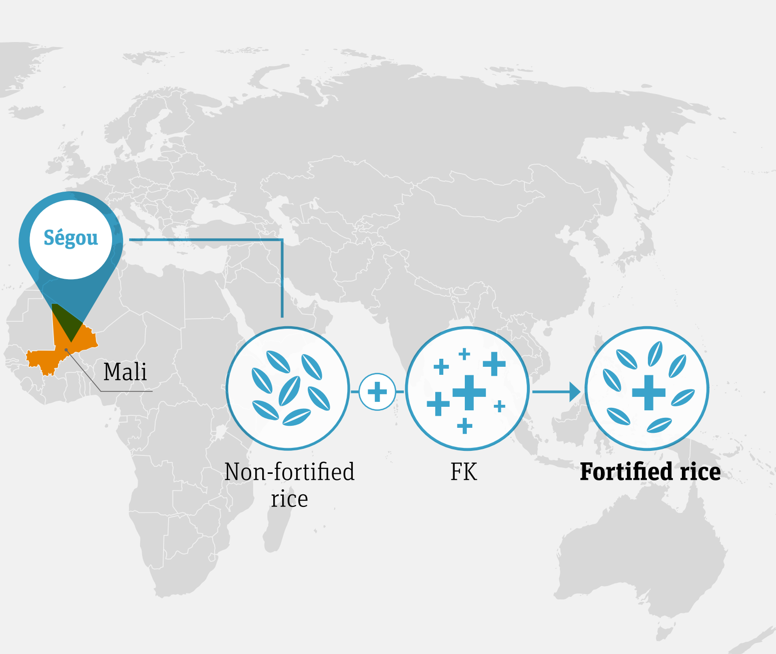
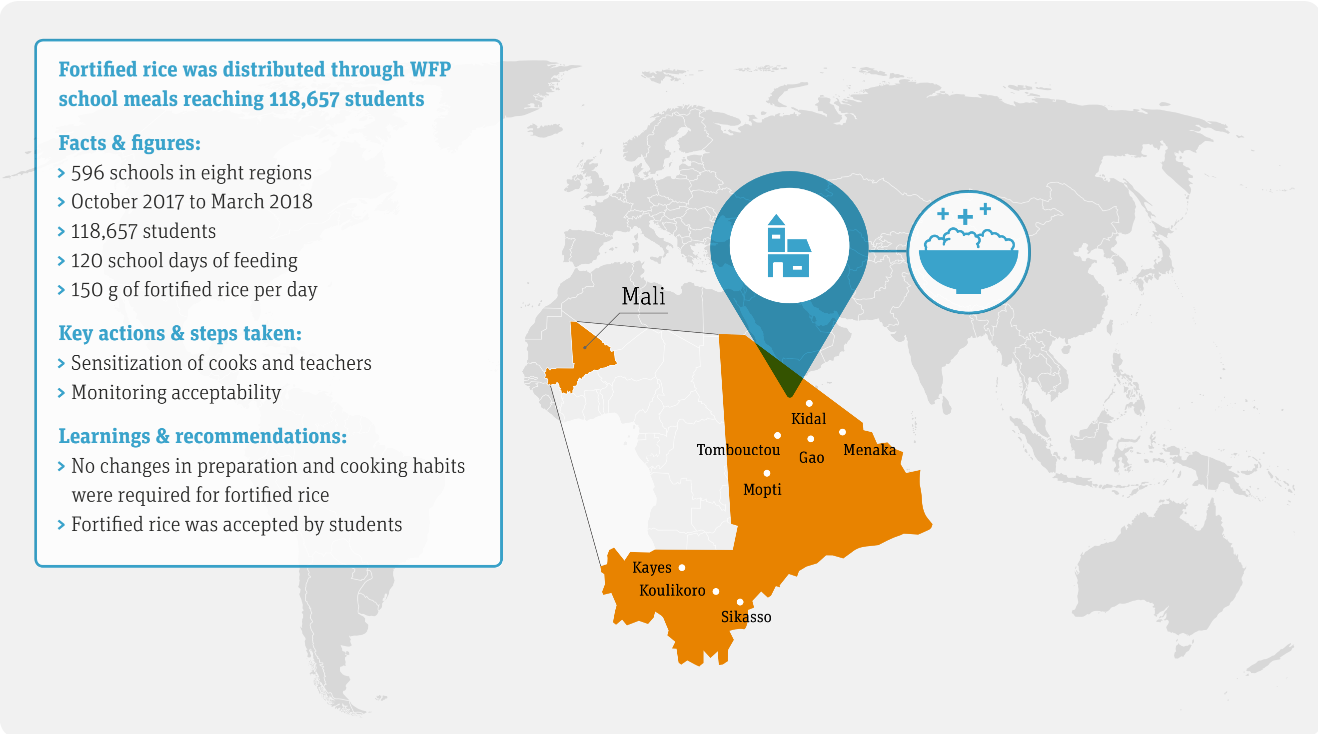


FIGURE 5: Distributing fortified rice in WFP school meals



carried out to ensure that rice would be prepared, cooked, and served appropriately (**Figure 5**). Focus group discussions conducted with parents, cooks and students revealed that including fortified rice in the school meals was favorably perceived. No problems were encountered with preparation, and children 'appreciated' the taste of fortified rice.

Discussion and recommendations

After one year of program implementation the project found that it is technically possible to fortify rice in Africa using imported FK blended with local non-fortified rice. Once cooked, the fortified rice mimicked local rice and was accepted by all beneficiaries. In total, 1,500 MT of rice were fortified, reaching 118,657 beneficiaries who accessed fortified rice over 120 school days. The cost of fortification was US$32 per MT, representing a 5% increase compared to cleaned and calibrated local non-fortified rice. Based on a 120-day school year and 18 kg distributed per child per school year, in total it cost the project US$0.94 more per child to substitute locally procured non-fortified rice with fortified rice (**Table 1**).

Operating fortification of rice is a cross-functional exercise that requires collaboration with and between government entities, the private sector and civil society, both at the national and the international level. Coordination and ownership of the project are critical factors to ensure adequate follow-up on activities, diffusion of information and communication across teams. From an operational standpoint, a number of key considerations and strategic actions should be considered going forward for program implementation:

FK production:

- Large batches through aggregation of demand and standardization of specifications are required in order to ensure homogeneity of batches of FK produced.

TABLE 1: Operating expenses

Cost categories	Cost | MT	Percentage
Cleaned and calibrated non-fortified rice (1,485 MT)	US$530.78	88.31%
Non-fortified rice cleaning, calibrating & material handling costs	US$20.12	3.35%
By-products/impurities (50 MT)	US$17.86	2.97%
Fortification costs	US$32.28	5.37%
Total cost for 1,500 MT of fortified rice	**US$601.04**	**100%**

TABLE 2: Operating cost breakdowns

Operating costs	Percentage
Clean, calibrated non-fortified rice	88.31%
Electricity/diesel	0.19%
Packaging	1.35%
Production workers	1.25%
Material-handling laborers	0.73%
Management staff	0.92%
Losses (impurities, stones, weighing differences)	0.02%
By-products (broken kernels, rice bran)	2.95%
FK	3.80%
FK transport and clearance	0.47%
Total cost of fortified rice	**100.00%**

- Ensuring that a competitive pool of FK-certified suppliers is built to enhance competition, reduce lead times and improve quality and consistency in general.

FK blending

- The model operated under this project meant that selecting the right partner to operate the blending step was the cornerstone of the project's success. A detailed assessment of the local rice fortification supply chain should systematically be performed at inception phase to investigate best operational solutions based on the capabilities and capacities of local millers and other potential partners to integrate the value chain – from rice procurement to milling, sorting, blending and repackaging.

Rice cleaning, grading and fortification operations, Ségou, Mali, September 2018


© Malô

FK classification

- For WFP programs, reclassification of FK as a food item within WFP's nomenclature is needed for budget systems, product quality control, traceability and reporting purposes.

FK shelf life

- At scale, and given the relatively short shelf life of FK (12 months), it will be important to work with suppliers to minimize lead times especially in cases where FK are pre-positioned for a long period of time.

Import process

- Anticipating arrival, documentation and approval requirements are needed in-country to optimize total import times.

This project provided detailed information on the different costs incurred by the fortification partner in cleaning non-fortified rice, calibrating it and fortifying it. It showed that the financial burden of the logistics setup tested relations with the fortification partner, who takes on all the financial and technical risks. For small- and medium-sized enterprises and cooperatives in countries where interest rates are extremely high, pre-financing the cost of key raw materials (non-fortified rice and FK) represents a considerable upfront investment and cash flow risk.

The cost of non-fortified rice is the number one input for fortified rice, as illustrated in **Table 2**. It is the main driver of all costs, representing 88% of the total cost of fortified rice for this project. Sourcing quality non-fortified rice was the most difficult initial obstacle for Malô, both technically and financially. In order to obtain the required 1,485 MT of non-fortified rice necessary for the project, Malô had to purchase, process, and calibrate 1,535 MT of non-fortified rice prior to blending it with FK, representing a 3% loss (50 MT) in by-products and losses. Sourcing quality non-fortified rice is therefore the most capital-

TABLE 3: Fortification costs

Fortification costs categories	Cost | MT
Electricity/diesel	US$0.45
Production workers	US$ 1.78
Material-handling laborers	US$ 2.77
Management staff	US$ 1.60
FK cost	US$22.87
FK transport & clearance	US$2.81
Total fortification cost/MT	**US$32.28**

A Malô production worker stitching 50 kg bags of fortified rice prior to final storage, Ségou, Mali, August 2018

intensive activity and the one that represents the biggest financial burden for the fortification partner.

As shown in **Table 2**, out of the 10 cost categories identified during the procurement, cleaning, calibrating and fortification process, two cost drivers stand out: FK importation and by-products. By-product losses represented 70% of the cost of importing FK from Thailand and thus constitute a key priority area for cost optimization by grinding broken non-fortified rice kernels into rice flour – the main ingredient in FK production.

Additional actions identified throughout the project to consider for cost optimization include:

FK cost

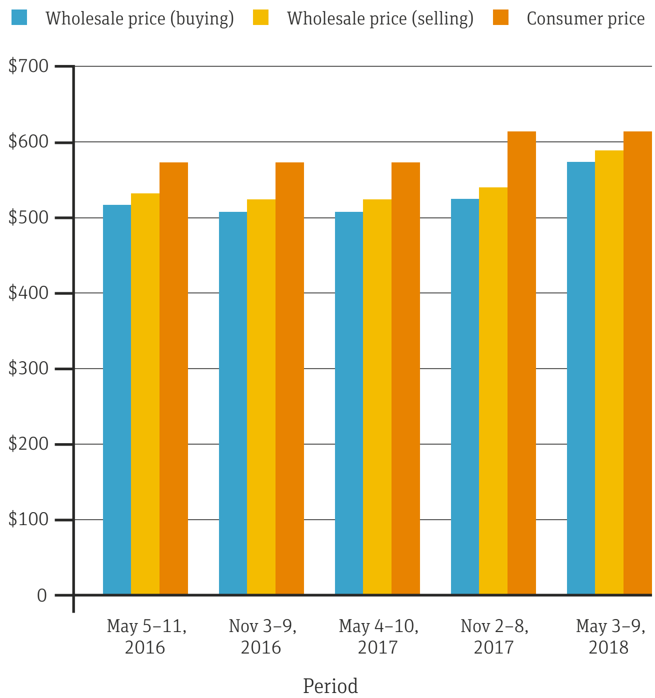
- To reduce the unit cost of FK, a volume leveraging strategy should be pursued that will consist of standardizing FK specifications globally with a view to aggregating demand across programs, partners and governments already implementing rice fortification.

Sourcing quality non-fortified rice

- A cost-effective approach to sourcing non-fortified rice will be to use varieties for which supply is abundant throughout the country and which face less commercial pressure.
- Pre-financing farmer cooperatives' rice-growing costs represents a win-win situation for the farmers and the fortification partner.
- By providing farmers with quality seeds and fertilizers in exchange for contractually agreed-upon prices and quantities of paddy or non-fortified rice, farmers would reduce their bank financing needs and costs, while the fortification

FIGURE 6: Gambiaka rice price variations in Ségou 2016–2017[6]

Evolution of wholesale and consumer prices (May 2016 to May 2018)



partner would be better able to ensure quality control from planting to milling, reduce uncertainty/volatility related to prices and availability, and be more competitive.

In addition, the project highlighted that the cost of local non-fortified rice is highly subject to demand and supply forces and varies significantly throughout the year based on harvest quality, stock availability and consumer preferences. Supply is generally tight as the country enters the lean season and loosens up according to the productivity of the new harvest. This seasonality is illustrated in **Figure 6**. From November 2017 to May 2018, the cost of Gambiaka in Ségou increased by nearly 9%, while fortification was calculated to increase the cost of non-fortified rice by about 5%.

Given the potential of rice as a vehicle to reach beneficiaries globally, improving access to quality, affordable and locally produced non-fortified rice globally is vital to rice fortification efforts. This is something that WFP has already embraced through its leadership of the Missing Middle Initiative project[5] which aims to strengthen Malian rice producer organizations by improving the quality of paddy and non-fortified rice and attracting private sector investment in the rice supply chain.

Conclusion

This project aimed to provide lessons related to programming distribution of fortified rice through WFP school meals with a view to documenting operational challenges and giving direction on opportunities to explore for optimization and replication within the West Africa region. Despite the challenges the project can be considered a success in that it highlighted critical organizational and operational factors that should be monitored before and during implementation.

The project opened new avenues to explore for optimization and further reduction of the various fortification costs. The model tested, whereby fortified rice was produced through imported FK that was then domestically blended, has shown that in addition to contributing to the well-being of beneficiaries, rice fortification also stimulates the local economy through the purchase of local products and job creation. In total, 1,300 members of Faso Jigi contributed non-fortified rice to the project and Malô created 40 full-time jobs, including production staff, supervisors and quality control managers.

Mali is experiencing food and nutrition insecurity linked to difficult agro-climatic conditions and a high level of poverty, exacerbated since 2012 by the political and security crisis. At least 50,000 new displaced persons are expected in 2018 in Mali and WFP, along with other partners, plans to provide emergency food and nutrition assistance to cover their immediate food and nutritional needs. Safety net programs through cash transfers, food vouchers or school meals will enable the poorest to access balanced food baskets. In this context, making fortified rice more accessible locally is an intervention that has the power to significantly contribute to the local economy while also improving food security, nutrition and the well-being of populations at risk.

Students enjoying fortified rice, Koulikoro, Mali, January 2018

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Guideline:[1] Fortification of Rice with Vitamins and Minerals as a Public Health Strategy

Executive Summary

Fortification of staple foods, when appropriately implemented, can be an efficient, simple and inexpensive strategy for supplying additional vitamins and minerals to the diets of large segments of the population. Rice is cultivated in many parts of the world as it grows in diverse climates. Industrial fortification of rice with vitamins and minerals has been practiced for many years in several countries in the World Health Organization (WHO) Eastern Mediterranean Region, Western Pacific Region and Region of the Americas where rice is a staple consumed regularly in the preparation of many common local dishes.

Decisions about the types and amounts of nutrients to add to fortified rice are commonly based on the nutritional needs and gaps in dietary intake of the target populations; the usual level of consumption of rice; the sensory and physical effects of the fortificant on the rice kernels; the fortification processing used in the production of the fortified kernels; the availability and coverage of fortification of other staple food vehicles; the population consumption of vitamin and mineral supplements; the costs; the feasibility of implementation; and the acceptability to the consumers.

Rice kernels can be fortified with several micronutrients, such as iron, folic acid and other B-complex vitamins,[2] vitamin A and zinc – some are used for restitution of the intrinsic nutritional contents prior to milling and others are used for fortification purposes. Their bioavailability will depend, importantly, on the processing used in the production of the fortified kernels.

Purpose of the guideline

This guideline provides global, evidence-informed recommendations on the fortification of rice with micronutrients as a strategy to improve the health status of populations.

It aims to help Member States and their partners to make informed decisions on the appropriate nutrition actions to achieve the 2030 Sustainable Development Goals[3] and the global targets set in the *Comprehensive Implementation Plan on Maternal, Infant and Young Child Nutrition*.[4]

The recommendations in this guideline are intended for a wide audience including policy makers, their expert advisers and technical and program staff in ministries and organizations involved in the design, implementation and scaling up of nutrition actions for public health.

The guideline complements the WHO/FAO (Food and Agriculture Organization of the United Nations) *Guidelines on Food Fortification with Micronutrients*[5] and the Pan American Health Organization document, *Iron Compounds for Food Fortification: Guidelines for Latin America and the Caribbean 2002*.[6]

Summary of the evidence

A Cochrane systematic review on fortification of rice with vitamins and minerals for addressing micronutrient malnutrition included 16 studies (14,267 participants). The search strategy was conducted in 2012 and updated in 2017. Twelve were randomized controlled trials (5,167 participants) with 10 involving children in urban and rural settings and two studies involving non-pregnant non-lactating women. Four studies were controlled before-and-after studies (9,100 participants). The 16 selected studies reported fortification with iron. Of these, six studies fortified rice with iron only; in 10 studies, other micronutrients were added (iron, zinc, vitamin A and folic acid). Five studies provided other B-complex vitamins. The control for all trials was unfortified rice. The iron content ranged from 0.2 mg to 112.8 mg/100 g uncooked rice, given for a period varying from two weeks to 48 months.

The review showed that the provision of rice fortified with vitamins and minerals including iron, when compared with unfortified rice, probably improves iron status by reducing the risk of iron deficiency by 35% and increasing the average concentration of hemoglobin by almost 2 g/L, but may not make a difference to the risk of anemia in the general population of those aged over two years. When the fortification of rice includes vitamin A it may reduce both iron deficiency and vitamin A deficiency. When fortification includes folic acid, fortified rice may slightly increase serum folate concentrations.

In addition to the direct and indirect evidence (vitamins and minerals delivered using food vehicles other than rice) and its overall quality, other considerations were taken into account by the guideline development group to define the direction and strength of the recommendations. They included values and preferences of the populations related to fortification of rice in different settings, trade-off between benefits and harms, costs and feasibility.

For developing the recommendations, the guideline development group considered the certainty of the existing evidence,[7] values and preferences, costs, baseline prevalence of anemia and/or other nutritional deficiencies, equity and the feasibility of implementation.

Recommendations

- Fortification of rice with iron is recommended as a public health strategy to improve the iron status of populations in settings where rice is a staple food.[8] (*strong recommendation,*[9] *moderate-certainty evidence*).
- Fortification of rice with vitamin A may be used as a public health strategy to improve the iron status and vitamin A nutrition of populations (*conditional recommendation*,[10] *low- certainty evidence*).
- Fortification of rice with folic acid may be used as a public health strategy to improve the folate nutritional status of populations (*conditional recommendation*,[11] *very low-certainty evidence*).

Remarks

The remarks in this section are intended to give some considerations for implementation of the recommendations, based on the discussion of the guideline development group.

- The number and amounts of nutrients should be adapted according to the needs of the country. If other fortification programs with other food vehicles (i.e., wheat flour, maize flour or corn meal) and other micronutrient interventions are jointly implemented effectively, these suggested fortification levels need to be adjusted downwards as necessary. A combined fortification strategy using multiple vehicles appears to be a suitably effective option for reaching all segments of the population.
- There are several methods available for the fortification of rice. The method chosen depends on the local technology available, costs, and other preferences. The process of adding nutrients to rice through dusting reduces the number of nutrients consumed in settings where rice is commonly washed before cooking. In particular, washing and cooking practices among a population are important considerations in selecting a method for fortification of rice. For example, rinse-resistant methods to ensure that nutrients are retained after washing will be important if rice is commonly washed before cooking.
- Rice milling results in the loss of a significant proportion of B vitamins and minerals that are found predominately in the outer germ and bran layers. Nutrient losses during milling can be minimized by a process called parboiling, in which raw rice is soaked in water and partially steamed before drying and milling, resulting in some of the B vitamins migrating further into the grain.
- Since some of the fat- and micronutrient-rich bran layers are removed during rice milling, the restoration of thiamine, niacin, riboflavin and vitamin B_6 in the fortification profile should remain a regular practice in fortification.
- The prevalence of depletion and deficiency of vitamin B_{12} is high in all age groups, reaching 50% in some countries. The inclusion of vitamin B_{12} is recommended when staples are fortified with folic acid to avoid the masking effect of folic acid on vitamin B_{12} deficiency.
- Fortification of rice with iron has been a challenge since most of the bioavailable iron powders used in food fortification are colored, which produces changes in the aspect of fortified kernels compared to unfortified ones. Ferric pyrophosphate has been the choice for rice fortification because it is a white powder, although its bioavailability is low.[12] In human absorption studies, the addition of enhancing compounds such as citric acid/trisodium citrate mixtures has been linked to an increase in iron absorption from ferric pyrophosphate.[13]
- Mandatory rice-fortification programs can only be effective if they are properly implemented and legislation is enforced.
- Food fortification should be guided by national standards, with quality assurance and quality control systems to ensure quality fortification. Continuous program monitoring should be in place as part of a process to ensure high-quality implementation. Monitoring of consumption patterns and evaluation of micronutrient status in the population can inform adjustment of fortification levels over time.
- Rice fortification on a national scale requires a large, cost-effective and sustainable supply of fortified kernels.
- In malaria-endemic areas, the provision of iron through rice fortification as a public health strategy should be done in conjunction with public health measures to prevent, diagnose and treat malaria.

- Behavior-change communication strategies may be necessary for overcoming barriers and creating and maintaining demand for fortified rice.

References and notes

1. This publication is a World Health Organization (WHO) guideline (Guideline: fortification of rice with vitamins and minerals as a public health strategy. Geneva: World Health Organization; 2018. Licence: CC BY-NC-SA 3.0 IGO Executive summary, pages 1-4. Geneva: World Health Organization; 2018. Accessed from: www.who.int/nutrition/publications/guidelines/rice-fortification/en/ on 18 June 2018). A WHO guideline is any document, whatever its title, containing WHO recommendations about health interventions, whether they be clinical, public health or policy interventions. A recommendation provides information about what policymakers, healthcare providers or patients should do. It implies a choice between different interventions that have an impact on health and that have ramifications for the use of resources. All publications containing WHO recommendations are approved by the WHO Guidelines Review Committee.
2. The B-complex vitamins include B_1, thiamine; B_2, riboflavin; B_3, niacin; B_6, pyridoxine; B_9, folate; and B_{12}, cyanocobalamin. Thiamine, riboflavin, niacin and folic acid are commonly referred to by name and their names are used throughout this document; the others are referred to by vitamin number.
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7. The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach defines the overall rating of confidence in the body of evidence from systematic reviews as the extent to which one can be confident of the effect estimates across all outcomes considered critical to the recommendation. Each of the critical outcomes had a confidence rating based on certainty of evidence – high, moderate, low, or very low. High-certainty evidence indicates confidence that the true effect lies close to that of the estimate of the effect. Moderate-certainty evidence indicates moderate confidence in the effect estimate and that the true estimate is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different. Low-certainty evidence indicates that confidence in the effect estimate is limited and the true effect may be substantially different from the estimate of the effect. Very low-certainty evidence indicates very little confidence in the effect estimate and the true effect is likely to be substantially different from the estimate of effect.
8. A staple food, or simply a staple, is a food that is consumed regularly and provides an important proportion of the energy (calories) and nutrient requirements. Its preparation is variable in different contexts and is closely linked to the most available foods in each place.
9. A strong recommendation is one for which the guideline development group is confident that the desirable effects of adherence outweigh the undesirable effects. Implications of a strong recommendation are that most people in these settings would desire the recommended fortification of rice with iron and only a small proportion would not. For policymakers, a strong recommendation indicates that the recommendation can be adopted as policy in most situations.
10. A conditional recommendation is one for which the guideline development group concludes that the desirable effects of adherence probably outweigh the undesirable effects, although the trade-offs are uncertain. Implications of a conditional recommendation for populations are that while many people would desire fortification of rice with vitamins and minerals, a considerable proportion would not. With regard to policymakers, a conditional recommendation means that there is a need for substantial debate and involvement from stakeholders before considering the adoption of fortification of rice with these vitamins and minerals in each setting.
11. A conditional recommendation is one for which the guideline development group concludes that the desirable effects of adherence probably outweigh the undesirable effects, although the trade-offs are uncertain. Implications of a conditional recommendation for populations are that while many people would desire fortification of rice with vitamins and minerals, a considerable proportion would not. With regard to policymakers, a conditional recommendation means that there is a need for substantial debate and involvement from stakeholders before considering the adoption of fortification of rice with these vitamins and minerals in each setting.
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Rice Fortification

An Opportunity to Improve Nutrition in West Africa

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Introduction

A two-day workshop, Rice Fortification – An Opportunity to Improve Nutrition in West Africa, took place in Dakar, Senegal on November 27–28, 2017. This event brought together over 50 stakeholders, including country delegates and global and regional technical partners, to raise awareness and discuss opportunities and challenges around rice fortification and its potential role in improving dietary quality and reducing micronutrient deficiencies in the region.

Country delegates in attendance came from Benin, Côte d'Ivoire, The Gambia, Ghana, Guinea-Bissau, Liberia, Nigeria, Senegal and Mali. One representative from Madagascar, which is outside the region, also attended. This two-day event was organized by the UN World Food Programme (WFP) with the support of an Organizing Committee that included members from the UN Food and Agriculture Organization (FAO), the Food Fortification Initiative (FFI), the Global Alliance for Improved Nutrition (GAIN), Helen Keller International (HKI), Nutrition International (NI), *Sight and Life* (SAL), and the United Nations Children's Fund (UNICEF).

Key objectives:

The key objectives of the workshop were to:

- share the latest global evidence on the impact of fortification on nutritional status;
- share operational experience on rice fortification in West Africa and from other regions;
- ensure an understanding of current rice fortification technology and delivery models;
- hold a general discussion on opportunities and challenges for rice fortification in West Africa; and
- determine outstanding information needs to further rice fortification efforts in West Africa.

Facilitated by Jane Badham, the workshop combined plenary presentations with facilitated exchanges, interactive country delegation working groups, and moderated question-and-answer discussion sessions. Participants learned about the global evidence for rice fortification, technical aspects of production and the feasibility and potential for rice fortification in West Africa. Three country experiences were featured, which highlighted different delivery models: Costa Rica (mandatory), Bangladesh (safety net/voluntary/corporate social responsibility), and Mali (school meals using imported fortified kernels blended with locally produced rice). Throughout the workshop, technical presentations gave the opportunity for country delegation teams to discuss the applicability and feasibility of rice fortification in their respective countries. The country teams concluded their discussions with specific action points to move rice fortification forward.

"Throughout the workshop, technical presentations gave the opportunity for country delegation teams to discuss the applicability and feasibility of rice fortification in their respective countries"

Highlights of the workshop

Participants were welcomed to the event by Dr Laila Lokosang, Senior CAADP (Comprehensive Africa Agriculture Development Programme) Advisor, Food Security and Nutrition at the African Union Commission Department of Rural Economy and Agriculture. In his opening speech Dr Lokosang highlighted that a multisectoral approach to nutrition is key to the Africa Regional Nutrition Strategy and that fortification is a cost-effective nutrition intervention that needs to be scaled up in Africa over the

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Group photo at the Rice Fortification workshop in Dakar, Senegal

next decade. Lauren Landis, Global Director of WFP's Nutrition Division, and William Affif, Senior Regional Programme and Policy Advisor for West and Central Africa for WFP, also highlighted the important role that fortified rice can play in reducing micronutrient deficiencies in the region.

The aim of the first session was to give insight into the nutrition and rice fortification landscape in West Africa. This was communicated through an interactive quiz in which participants' knowledge of nutrition deficiencies and consumption in West Africa was put to the test and results communicated instantaneously, followed by a discussion. Greg Garrett (GAIN), Dr Noel Zagre (UNICEF), Dr Balla Moussa Diedhiou (NI) and Dr Mawuli Sablah (FAO) made sure to answer any outstanding questions from the audience and provided more detail where necessary.

This informative session also served as an ice-breaker and helped set the stage for the first presentation of the workshop which was given by Fred Grant (HKI). This provided an overview of food fortification strategies in the region, recapping the various steps in fortification and further explaining six common strategies that have been adopted across the region, namely:

1. Prioritizing feasibility and scale
2. Leveraging regional coordination and leadership
3. Facilitating national-level action and commitment
4. Assessing and building public and private sector capacity
5. Mobilizing communities and sensitizing the population
6. Monitoring, evaluating and reassessing

This introductory presentation provided an important backdrop against which all fortification efforts should take shape – namely, the added value in looking at rice fortification in the context of a broader public health environment, with complimentary strategies to fill the micronutrient gap. Furthermore, the presentation emphasized that it was the complementarity of regional actions and country actions that led to progress. This effort should be further encouraged in light of the current window of opportunity which did not exist 15 years ago. In countries where fortification has already begun, there is an opportunity to reassess the situation, investigate to what extent the needs of the population are currently being met, explore improved ways of linking fortification data within national health information systems, and consider new micronutrients, vehicles and technologies.

The second session gave an overview of the basics of rice fortification, laying out the various approaches that exist to address micronutrient deficiencies and underscoring that rice is widely consumed throughout West Africa. As it is an important staple food for much of the population, it should be added to the existing list of fortified staple foods (wheat and maize flour, condiments and oil). Existing rice fortification technologies (parboiling, dusting, coating and extrusion) were also introduced, as well as considerations in selecting the best option. The main takeaway was that rice fortification can be done with the existing technology yet the chosen fortification technology must be context-specific and must also be in line with a country's rice preparation and cooking habits.

Participants hard at work shaping the future of rice fortification in West Africa

The next presentation looked at the evidence for impact of rice fortification. Dr Saskia de Pee (WFP) and Dr Diego Moretti (ETH) addressed many common questions concerning the acceptability, bioavailability, nutrient losses, adequate nutrient levels and other requirements for effective rice fortification, and explained the target of ensuring that the nutrient intakes are above the Estimated Average Requirement (EAR). The key message was that rice fortification is a safe and highly acceptable method for the population and its contribution to micronutrient status has been proven. Efforts are now required to implement at scale, beginning with deciding jointly to pursue fortifying rice and focusing on how to implement this.

Country case studies

The following session focused on rice fortification delivery options and shared country experiences. Jose Antonio Martinez Fonseca (Executive Director, INDUARROZ) presented the mandatory fortification model being implemented in Costa Rica, and Bikash Das (Ministry of Planning, Bangladesh) shared experiences around voluntary rice fortification in social safety net programs and corporate social responsibility.

Anna Horner (WFP) explained how in Mali, WFP – together with Malô (a local social enterprise founded by young entrepreneurs) – is implementing a groundbreaking project in West Africa that aims to test whether imported fortified kernels mixed with local rice could work as a sustainable business model. She said that, since October 2017, 1,500 metric tons of fortified rice had been produced through this model for distribution by WFP to children in the national school feeding program. Moving forward, Malô aims to extend production facilities beyond its current factory in Segou to the cities of Bamako and San in 2018 and to produce fortified kernels and manufacture Supermalô fortified rice for the population using locally grown rice and locally produced fortified kernels.

Mali's social safety rice fortification example has also proven that local rice fortification not only addresses micronutrient deficiencies but also creates economic and job opportunities, particularly among young people. It also demonstrates the feasibility of distributing this fortified rice through existing social safety net programs. The story of Malô –shared by its founder, Salif Romano Niang, on p. 76 of this issue – is an inspiring and eye-opening one that teaches us that implementation barriers are good to experience: "There will be challenges," concedes Salif, "but if you do not take any risks, you will not know what the challenges and opportunities are."

A presentation by Scott Montgomery (FFI), "Feasibility and Potential for Rice Fortification in West Africa," extended the focus to the wider West African region and gave a high-level overview of the supply chain in West African countries, which consume more than 75 g of rice per day. The main message was that collaboration across countries will be key to scale up rice fortification and to consolidate demand for fortified rice. The presentation entitled "Integrating Rice Fortification into Supply Chains for Cost-efficiency" looked at key characteristics from the country case studies to establish some of the lessons learned from rice fortification and, more specifically, what the

TABLE 1: The role of stakeholders in rice fortification

Government	Policy framework
	Political will and commitment to leadership
Private sector	Developing and reinforcing the technical capacity to produce quality fortified kernels and fortified rice
	Advocacy to develop an enabling environment
International organizations	Resource mobilization
	Knowledge transfer and technical support
Regional bodies	Regional mobilization | Multisectoral coordination
	Harmonized monitoring & evaluation framework | Standards and legislation
Civil society	Communication & advocacy
	Watchdog function to protect the consumer

key factors are for feasibility. Rizwan Yusufali (Technoserve) identified the following key points here:

Key factors for integrating rice fortification into supply chains for cost efficiency

1. Scale must be sought for a higher impact on micronutrient deficiencies and to establish what the real cost is.
2. It is essential to understand and map the rice value chains in order to identify at what levels fortification becomes feasible.
3. Engaging with the private sector at an early stage is necessary for all delivery models.
4. A supportive legislation and policy framework, which does not add an additional administrative and compliance burden, is important.

The role of stakeholders in rice fortification

The second and final day of the workshop focused on the 'how' of fortifying rice in West Africa. A brainstorming exercise on the role of stakeholders underlined the importance of early multi-stakeholder collaboration across the rice fortification process. **Table 1** shows the main key focus areas in which each stakeholder group can have the most impact in creating a favorable environment for rice fortification.

The session that followed, "Linking Rice Fortification Opportunities with Nutrition Objectives," built on the stakeholder exercise and emphasized the added value in bringing all stakeholders to the table. A methodology-focused presentation, "Fill the Nutrient Gap (FNG) study: Modeling the Potential of Rice Fortification for Improving Micronutrient Intake among Different Target Groups," is a good example of this being put into practice, whereby, through modeling methods, the FNG tool strengthens the nutrition analysis linked to decision-making and aims to establish consensus on cost-effective programmatic strategies to improve nutrition. Dr Saskia de Pee, lead of the FNG team, explained how the tool involves a variety of stakeholders throughout the process by enhancing dialogue across sectors. The FNG tool helps to bring all the relevant players to the same table and to find consensus with stakeholders in the country.

Rice fortification: one strategy toward achieving development goals

In this panel discussion, regional bodies including the African Union Commission, ECOWAS and the West African Health Organization (WAHO) gave their insights and elaborated on the close relationship between rice fortification and the achievement of the Sustainable Development Goals (SDGs). Dr Laila Lokosang (ECOWAS) and Dr Modibo Traore (WAHO) emphasized that while rice fortification clearly links to SDG 2.2, aiming to end all forms of malnutrition, it also has the potential to create jobs

Balla Moussa Diedhiou (NI), Noel Marie Zagre (UNICEF) and Greg Garrett (GAIN) (left to right)

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Introduction to the Iron Spot Test – a simple, rapid test that indicates qualitatively whether iron has been added to the flour

and reduce poverty, as confirmed through the Mali case study. Furthermore, they discussed how there are many political and economic aspects that are intrinsically linked to rice production. Rice fortification provides a window of opportunity to expose some of these issues and join forces to address these. If West Africa were to create a demand, it could have an impact in the entire region but also at the global level.

"Not only is rice a strategic commodity for West Africa; it can also be a pull factor aiming to bring the private sector to the table"

Not only is rice a strategic commodity for West Africa, it can also be a pull factor aiming to bring the private sector to the table. Moreover, rice has a privileged position: the significant amount of rice imports represents a quick and yet tremendous opportunity to shift to fortified rice – "from rice to fortified rice is just a step." The region can also build on its experience with wheat, cereal and oil fortification and leverage its expertise in rice fortification. While the current collaborations are encouraging, it is now up to the region to pursue these and to make rice fortification a priority.

Meeting the experts, and the way forward

Country delegates gathered in four roundtables to discuss rice fortification topics with experts in various fields: rice fortification evidence and standards; rice fortification delivery models; rice fortification technologies and supply chain; and balancing a fortified food basket. This was an opportunity for participants to ask further questions on 'burning' issues.

Regarding the way forward and the next steps for participating countries, a session was dedicated entirely to in-country discussions in which country delegates reflected in small groups on key issues relevant to their specific context. Below are a few action points on rice fortification agreed by country delegations.

"We will include rice fortification as a point of discussion in our next meeting with the National Nutrition Council. It will be an opportunity to revisit regulations and reinvigorate this platform and add rice fortification to it."

"Presently in our country, local production of rice is being promoted by the government. This provides an opportunity to lobby the decision-makers to fortify imported rice at a national level."

"We will organize a multistakeholder meeting to discuss the strengths, comparative advantages, and benefits of rice fortification for the population."

"In our country, every effort should go toward reducing iron deficiency and anemia. We will initiate wide consultations and identify and include key stakeholders as part of our strategy and gather evidence that will support the adoption of rice fortification."

"I will present the rice fortification strategy to the members of the fortification committee at our next meeting in 2018 and discuss with WFP the potential of setting up a social safety net delivery model throughout school feeding programs."

"We will bring this good news where needed and will advocate to relevant stakeholders for our voice to be heard by the relevant government authorities (nutrition, agriculture, economy) as well as by the private sector and at the parliamentary level."

Summary

Micronutrient deficiencies are widely prevalent in West Africa. Despite programmatic responses aiming at combating these micronutrient deficiencies, rates remain high. Beyond the impact on morbidity and mortality, the social and economic effects of these deficiencies are devastating. Food fortification has been recognized as an important strategy for addressing this public health problem. Many countries have mandatory legislation on fortification of staple foods (such as wheat flour and edible oils) and salt.

Data presented at this workshop showed the large consumption of rice in a number of West African countries and a trend toward consumption of rice replacing other grains in the diet, but little in the way of efforts to scale up rice fortification in the region. Because of this, it was agreed that it is timely to consider fortification of rice in the overall approach to ensuring the availability of micronutrient-rich staple foods. It has the potential to fill a clear gap in the current fortification landscape. The evidence presented confirmed that with appropriate levels of micronutrients and appropriate fortificant forms, as well as with effective technology, fortified rice is an effective intervention to improve micronutrient status. Participants were thanked during the closing session and given a copy of the "Scaling up Rice Fortification in Latin American and the Caribbean" supplement of *Sight and Life* Magazine. To conclude, Scott Montgomery (FFI) and Lauren Landis (WFP) shared some closing remarks and summarized a set of opportunities that were discussed throughout the workshop.

"There is sufficient evidence to move ahead with scaling up fortified rice as part of an integrated approach to reduce micronutrient deficiencies"

There is sufficient evidence to move ahead with scaling up fortified rice as part of an integrated approach to reduce micronutrient deficiencies. In fact, not only does West Africa benefit from a large consumption of rice and a trend toward increased consumption, but rice has become a strategic commodity in the region and is rooted in the food security and politics of the region. The region already values and accepts fortification as other commodities (wheat, oil, cereal) are being fortified, thereby enabling countries to build on existing preliminary standards to make the case for rice fortification and to transfer, for instance, from voluntary to mandatory fortification. Nonetheless, despite the high level of interest in large-scale fortification in Africa, acceptability to the local context should be a key priority and there are other challenges to rice fortification that need to be taken into account, such as countries' needs to acquire the necessary technology and the need for financing more generally. Poor fortification in mandatory settings needs to be combated through increased monitoring, human resources, infrastructure, equipment, and, most importantly, political will. The need for champions to advocate rice fortification and advance its progress has never been greater, and it will be important to identify these at an early stage in the process. Finally, contextual and regional solutions should be developed and engagement with the private sector will be a key priority for any successful outcomes.

Africa's enabling environment shone throughout the workshop, revealing a relative consensus and a strong base of technical partners who can provide analysis and guidance and can share country experiences. This meeting was only a step in the journey. Participants agreed that they would debrief partners in their respective countries. Finally, it was jointly agreed that further sensitization among policymakers and other key decision-makers will be necessary and several organizations have already made this a top priority. WFP, for instance, is currently in discussion with key countries in the region to support the advancement of national-level dialogue and the inclusion of rice fortification in WFP program streams when appropriate, and also to conduct deep-dive landscape analysis for a few selected countries to generate a complete picture of potential delivery models for the region.

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 (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 B_{12} 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 B_1, B_6, 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 miniscule 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 providing 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 suboptimal 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.