



The role of rice fortification in improving public health

Executive summary

Malnutrition is a serious global issue, affecting most countries worldwide at varying levels. While often associated with individuals not having a high enough calorie intake, the lack of essential vitamins and minerals in daily diets is known as 'hidden hunger', and it has terrible consequences. As governments, non-governmental organizations (NGOs) and other interested parties look to address this problem in both the developed and developing worlds, food fortification offers an ideal solution for delivering crucial micronutrients to those in need.

As one of the world's most widely-consumed foods, rice is a promising vehicle for fortification to fill the nutrient gap of populations worldwide. Adding vitamins and minerals to rice helps to address a variety of nutritional needs in at-risk populations where rice is already a staple in daily diets. Advances in fortification technology ensure the added high-quality micronutrients remain stable in the kernels without requiring a behavior change from, or the education of, individuals. In addition to fighting malnutrition, fortified kernels can also be marketed to consumers looking to address specific health concerns, such as immunity and low energy levels.

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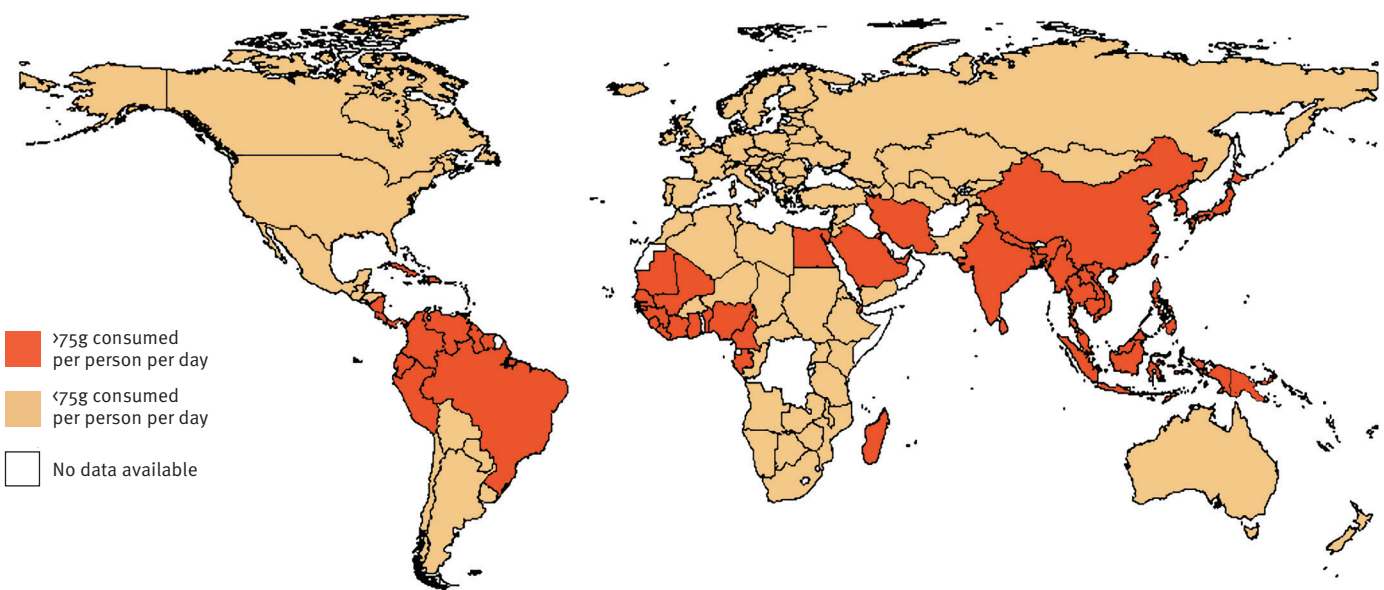
The role of rice fortification in improving public health

Rice: the world's most important food crop

Rice is one of the most commonly eaten foods in the world, providing more than 20% of the world's calorie intake - with approximately 480 metric tons of rice produced annually.¹ Figure 1 shows the levels of rice

consumption worldwide. As a staple food for over half of the global population, rice offers a good, and affordable, source of energy.

Figure 1: Map of worldwide rice consumption^{2,3}



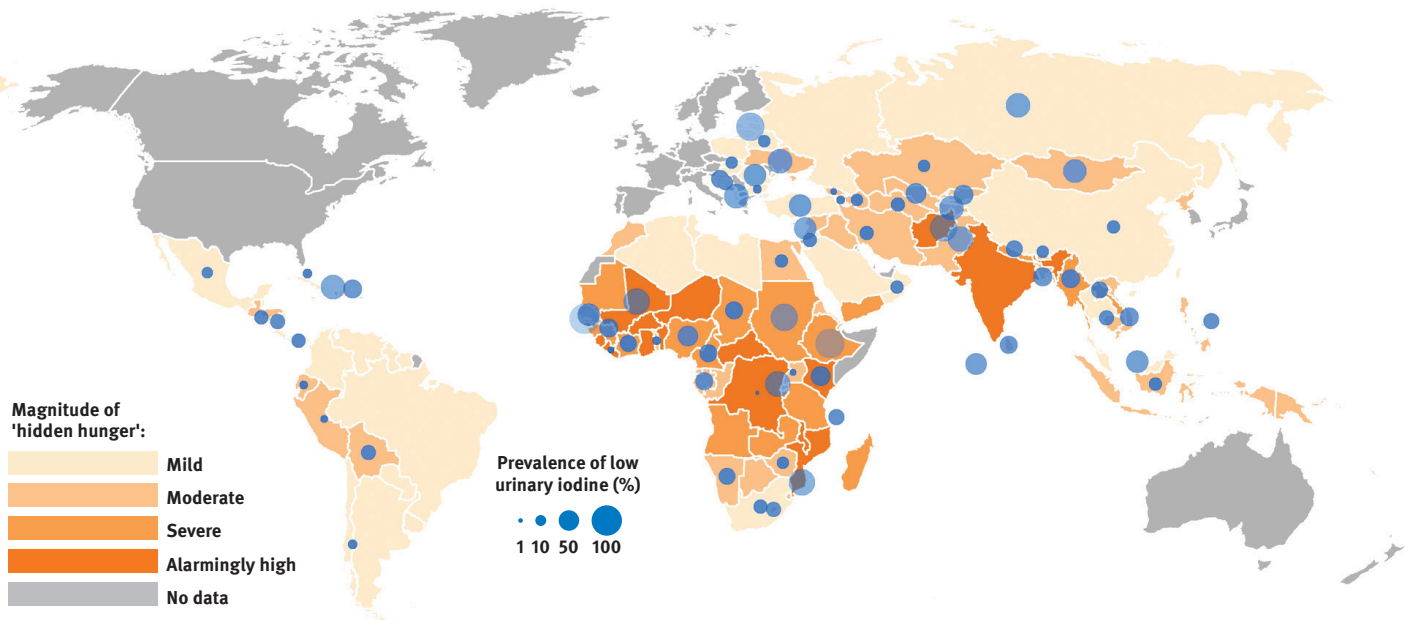
However, white rice does not provide significant amounts of most micronutrients (when compared to the daily recommended intakes). Additionally, the milling process that produces the commonly-consumed white rice also removes both the fat and nutrient-rich bran layers. Figure 2 demonstrates this point, showing the vitamins and minerals that are lost during the milling process.⁴

Figure 2: Chart showing the amount of vitamins and minerals lost from rice in the milling process⁵



The role of rice fortification in improving public health

Figure 3: Map of global 'hidden hunger'⁶



A lack of essential micronutrients can contribute to the phenomenon known as 'hidden hunger', where a person's diet includes enough calories, in some cases even an excess, but does not contain the

necessary vitamins and minerals needed for optimal health – leading to malnutrition. As shown in figure 3, 'hidden hunger' can be found in many countries across the globe.



The role of rice fortification in improving public health

Malnutrition across the world

Malnutrition is the single largest contributor to disease globally and is rife across the world, in various forms. It is estimated that one third of the global population suffers from micronutrient deficiencies.⁷ These deficiencies can have a detrimental impact on a person's health, as well as affecting wider society with increased public costs, decreased work capacity in populations and a tragic loss of human potential. Figures 4 and 5 show the prevalence of deficiencies in vitamins E and D worldwide.

In addition to being a public health concern, malnutrition has a wide economic impact. The economic costs, from lost productivity and economic growth, are as high as 11% of gross domestic product (GDP) in Africa and Asia each year.⁸

Figure 4: Global map of vitamin E status in healthy populations⁹

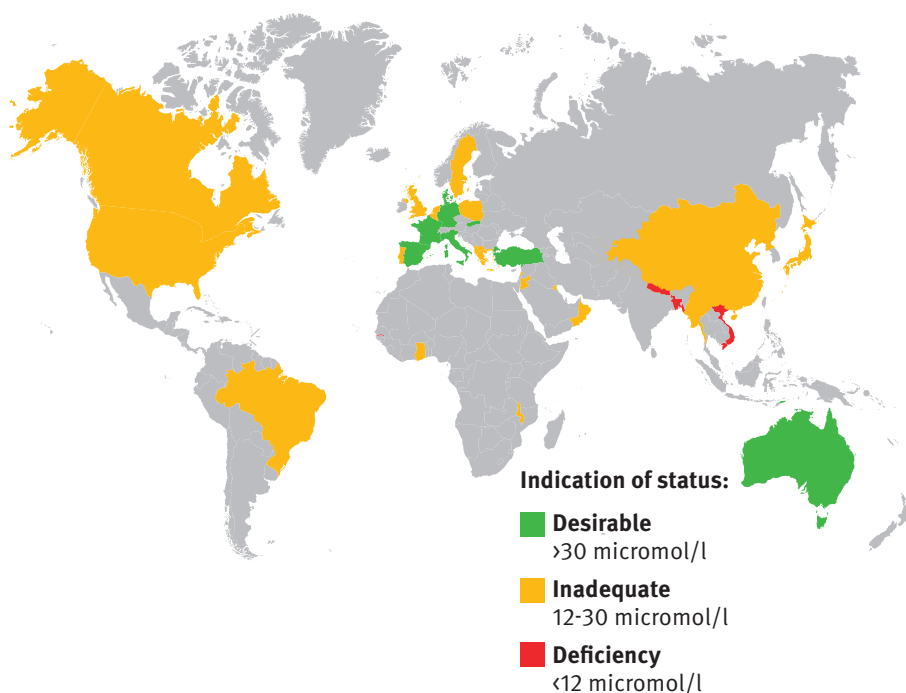
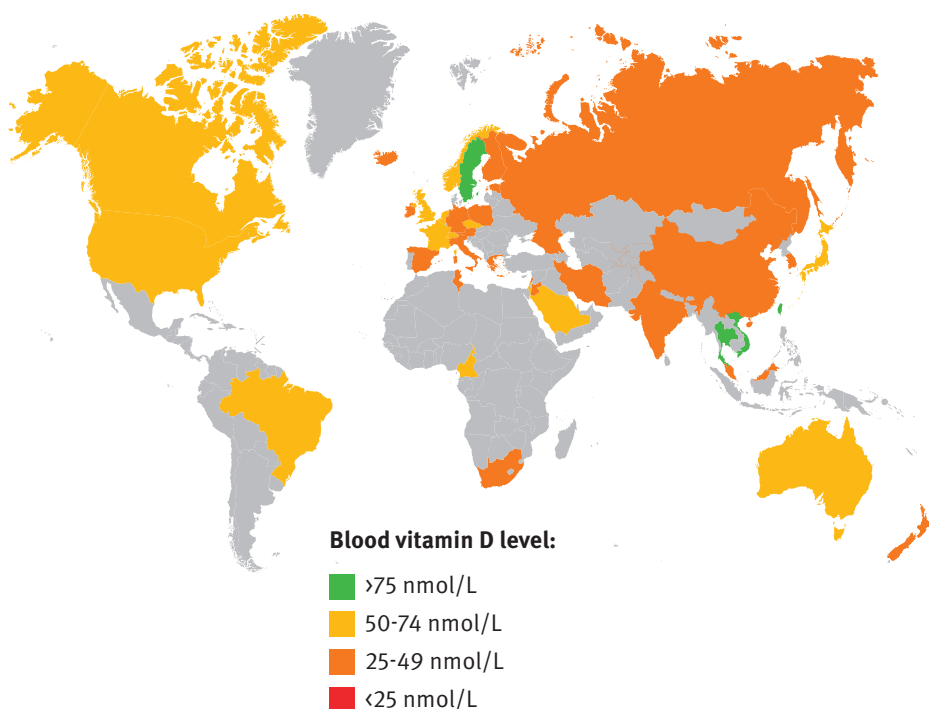


Figure 5: Global map of vitamin D deficiency in adults¹⁰



Malnutrition can lead to a variety of health issues, including increased risk of developing cardiovascular conditions and a weakened immune system. It is particularly dangerous in children, where it has been linked to stunting (a condition where a child is short for their age - a sign of chronic undernutrition) and poor cognitive development.¹¹ Across the world in 2016, 5.6 million children under the age of five died – half of whom suffered from conditions that are preventable. The most common causes of death in this age group are pneumonia, diarrhea and malaria, with malnutrition as the underlying contributing factor.¹²

The role of rice fortification in improving public health

Micronutrient deficiencies occur when an individual cannot achieve a healthy, balanced diet – whether this is caused by nutritious food not being affordable or accessible. Malnutrition, while present across the world, is particularly prominent in developing countries. It is estimated that approximately four billion people worldwide are living with incomes well below Western poverty lines with limited access to good nutrition, and are therefore trapped in a vicious cycle of income poverty (shown in figure 6).¹³

To break this cycle, it is vital that these groups have access to affordable, high-quality foods that can provide the levels of vitamins and minerals needed to support healthy lives.

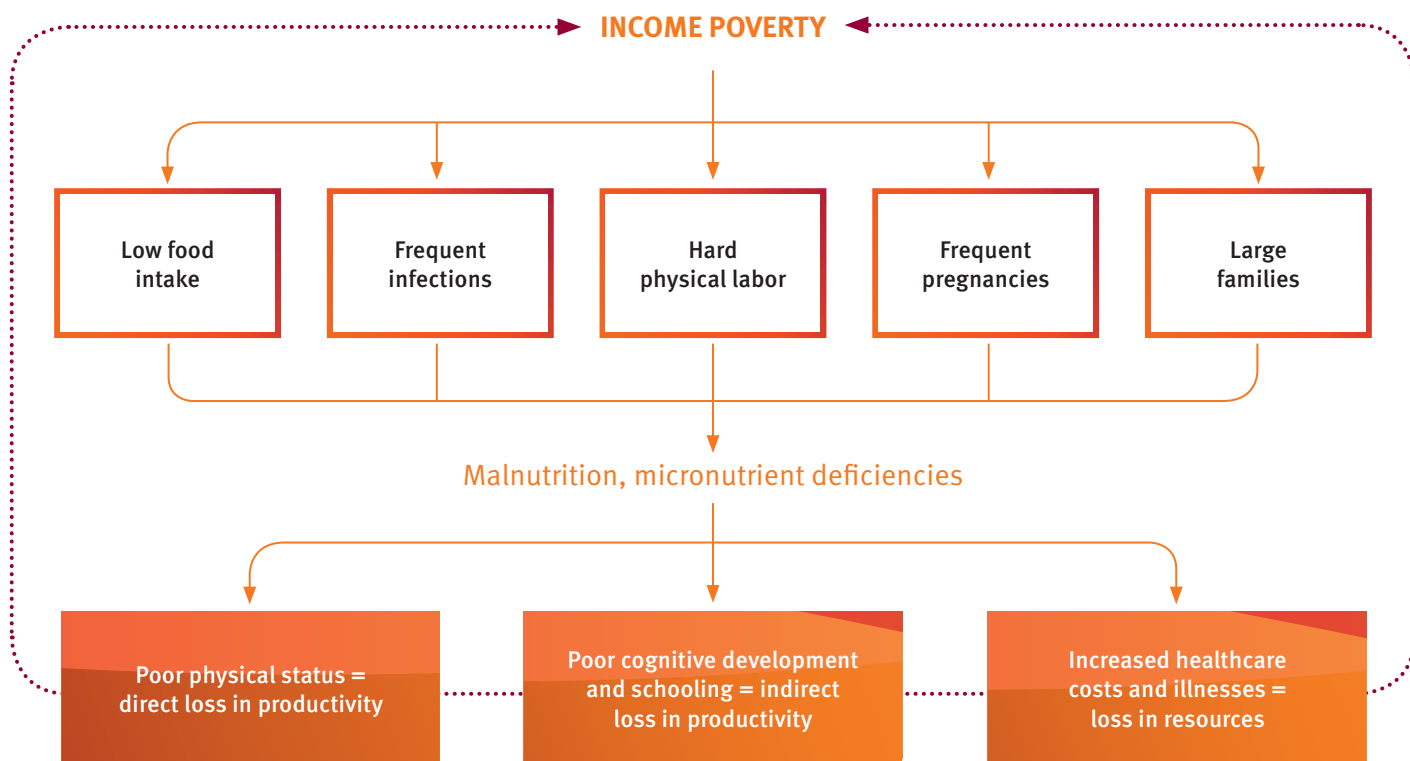


In 2015, the United Nations outlined 17 Sustainable Development Goals which aim to end poverty, protect the planet and ensure prosperity for all by 2030.



The second goal is 'Zero Hunger', which specifically addresses the need to end all forms of hunger and malnutrition across the globe.

Figure 6: Cycle of income poverty¹⁴



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Addressing malnutrition with fortified rice

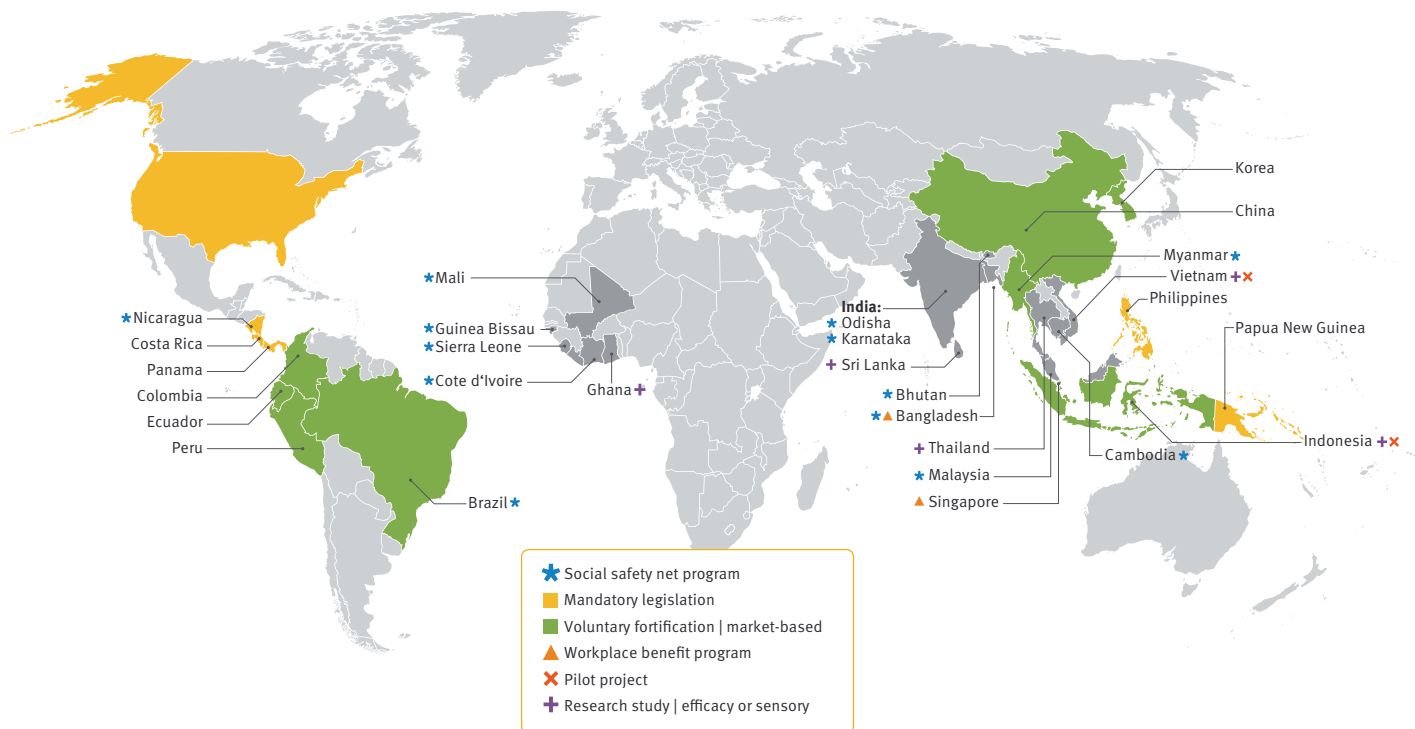
Tackling the global micronutrient deficiency epidemic requires work and engagement from a number of different organizations at various stages within the supply chain. As rice is widely consumed globally, adding vitamins and minerals to kernels through fortification presents clear opportunities to address malnutrition in millions of individuals.

Fortification, in its various forms, has been a popular method of improving public health for over 90 years and is mandatory for certain products in locations where populations are at particular risk of deficiencies in certain vitamins. Over 30% of industrially milled wheat flour and almost half of industrially milled maize flour is now fortified worldwide.

Efforts to fortify rice, on the other hand, are relatively new, with just 1% of industrially milled rice kernels on the market currently fortified.¹⁵ Fortunately for global health, this proportion is expected to increase significantly in coming years. This is due to the growing pool of scientific evidence substantiating the effects of rice fortification and increased support from governments and NGOs, as well as advancements in the technology that enable cost-effective methods of fortification. Figure 7 shows the prevalence of rice fortification worldwide.*

Rice fortification is currently mandatory in five countries (Costa Rica, Nicaragua, Panama, Papua New Guinea and the Philippines) and six states in the United States. Similar legislation is also being considered in several other countries, due to the successful results from fortification programs elsewhere. Additionally, a number of millers and brands across the globe are fortifying rice for commercial purposes.

Figure 7: Global status of rice fortification programs¹⁶



*Does not include research studies involving fortified rice, but includes pilot studies that are intended to demonstrate feasibility of rice fortification (rather than efficacy).

The role of rice fortification in improving public health

Ensuring efficiency in rice fortification methods

There are a number of different ways in which rice can be fortified, and the success of fortification programs can be influenced by the method selected.

Dusting

Kernels can be dusted with a micronutrient powder, relying on an electrostatic force to bind the dry powder to the surface of the grain. When considering dusting, it is important to note that the vitamins and minerals can be lost if the rice is washed before cooking or cooked in excess water – meaning consumers must be educated on the necessary methods of cooking and preparation.

Coating

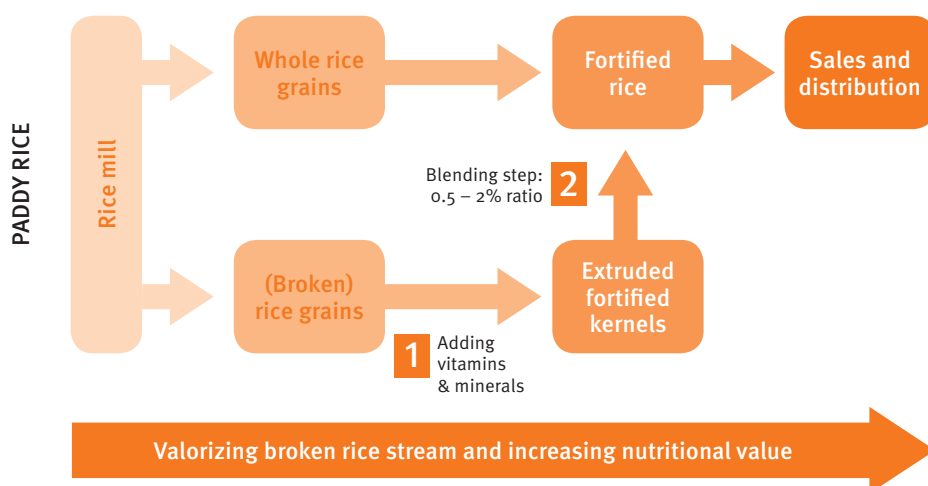
Rice can also be fortified using the coating method. This involves the use of a fortificant mix and ingredients such as wax or gum to 'fix' the micronutrient layer being sprayed onto rice. When using coating to fortify rice, it is crucial that the kernels are rinse-resistant to prevent loss of micronutrients through washing or soaking.

Hot extrusion

Hot extrusion fortification technology provides the most robust method of adding additional vitamins and minerals to rice. Nutrients are added to kernels in a simple two-step process as shown in figure 8. Firstly, broken rice grains are ground into rice flour and mixed with water and the required nutrients to produce a rice dough. The fortified dough is then passed through an extruder to produce the fortified kernels which are then blended with standard rice, most commonly in a ratio of 0.5-2%.



Figure 8: diagram of rice extrusion process



The vulnerability of these at-risk populations means the quality of the vitamins and minerals used in fortification programs is essential. It is vital that products can truly address the deficiencies of target populations if a real difference is to be made to human health. The stability offered by the hot extrusion method is ideal for guaranteeing that the high-quality micronutrients added to kernels are not compromised during transport, preparation or cooking.

The role of rice fortification in improving public health

The success of rice fortification

The popularity of rice makes it an ideal vehicle for fortification, and rice fortification programs offer a wealth of sustainable opportunities, both commercially and for public health. Improving the health of populations at risk of malnutrition or 'hidden hunger' worldwide means individuals are able to reach their maximum potential and contribute fully to society, while also decreasing public healthcare costs.

The success of extruded fortified kernels can be attributed to a number of factors.

Stability

Hot extrusion technology embeds the required micronutrients into the kernel, increasing the stability of the finished product. As the vitamins and minerals cannot be washed off or lost if the rice is cooked in excess water, there is no need to educate consumers or encourage them to change their behavior when preparing rice – a barrier that can arise when using the dusting and coating techniques.

Acceptability

Rice is already widely accepted as a food and eaten on a daily basis by many. The use of hot extrusion technology means that both the appearance and taste of the fortified kernels are similar to that of non-fortified rice. This means consumers can continue to enjoy rice as they have done previously, but with the benefit of the additional micronutrient content.

Flexibility

There are hundreds of varieties of rice available in the market, any of which can be fortified – from basmati to japonica. This ensures that consumer appeal can be maximized as there is no need for an individual to change their dietary habits to receive the benefits of fortification.

With different requirements from different populations, it is clear that a blanket approach would not be successful in reaching all those in need of the benefits of fortification. Fortunately, a wide range of micronutrient mixtures can be used to fortify rice, providing bespoke blends according to requirements. This means manufacturers have the capability to fulfil the needs of particular groups, such as the elderly or vulnerable individuals, as well as create solutions that appeal to individuals aspiring to address specific health concerns, such as immunity or brain health.

In addition to helping improve the nutritional status of at-risk people, rice fortification offers rice brand owners the opportunity to differentiate their products in a saturated market. By creating a healthier product that can address specific health needs, such as boosting energy levels or immunity, brands can appeal to new audiences, as well as gain a competitive edge.



Success story: fortified rice brands

The number of fortified rice products being launched to meet specific consumer demands is increasing. As well as giving general nutrition a boost, solutions that offer specific health benefits, such as improved energy or immune system support, are being developed by adding fortified kernels.



Success story: fortified rice in Costa Rica

The per capita rice consumption in Costa Rica is approximately 150g per day on average, accounting for about 30% of caloric intake. With a population of approximately four million, Costa Rica has a long history of government policies that aim to increase human health. As such, all rice for human consumption in the country is fortified with folic acid, vitamins B1, B3 and B12, selenium and zinc. Since this fortification program was introduced in 2001, the prevalence of anemia has significantly decreased, with a reduction of 71.2% among children aged one to six years and a reduction of 54% in people living in rural areas.^{17,18,19,20}

The role of rice fortification in improving public health

Conclusion

The rice market is constantly evolving and the established popularity of rice offers a unique opportunity to deliver crucial micronutrients to people across the world through safe and cost-effective fortification. Improving the nutritional status of those most at risk of malnutrition can help to break the poverty cycle, benefiting not only individuals but society as a whole, with increased citizen productivity and decreased healthcare costs.

Advances in fortification technology mean fortified rice can be delivered to those in need without requiring a change in consumer behavior, maximizing the likelihood of successful fortification programs. A successful program should consider the specific needs of target populations and deliver a complete and sustainable solution, ensuring products are both aspirational and accessible.

As fortified rice becomes more common, and countries worldwide look to implement

mandatory fortification legislation, it is essential that programs utilize high-quality vitamins, minerals and technology to ensure that malnutrition is addressed effectively. Brand owners looking to begin fortification programs should look to partner with experienced companies that can offer not only quality micronutrients, but also technological know-how and scientific backing to develop solutions that can make a difference to millions of people across the globe.

Key take-away messages

- 'Hidden hunger' is a global issue and causes a broad range of health problems, with tragic effects on both human life and society as a whole
- Rice is widely consumed in many developing countries, where deficiencies in essential vitamins and minerals are prevalent
- Rice is an ideal vehicle for fortification and, with the use of hot extrusion technology, offers a sustainable and cost-effective method of improving nutritional status globally, without requiring a change in consumer behavior
- The vulnerability of these populations means micronutrients used must be safe and high-quality to ensure significant improvement to human health
- The fortification of rice also offers a commercial opportunity for brand owners to differentiate their products in a saturated market, by offering specialty rice that addresses the specific health concerns of particular populations

Nutrition Improvement with DSM

DSM's Nutrition Improvement solutions aim to provide a comprehensive answer to the myriad challenges associated with improving nutrition. We are continuously working to deliver a range of nutritional products and technologies that have a proven impact on populations at risk of, or affected by, malnutrition. With experts in every field of public health improvement, our solutions can be provided as ready-to-use by beneficiaries, or can be further processed to suit the needs of particular groups. We also have expertise in creating appealing products for use in convenience and packaged foods, aimed at individuals in the developing world that aspire to achieve a healthier future. In this way, we are helping to ensure affordable nutrition is more accessible for all.



The role of rice fortification in improving public health

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