Extruded Rice Analogs to Fight Hidden Hunger

Violeta Sevillano Pires & Amal Gohar

Photo courtesy of DSM

Food Science in Action:

- ✓ Food processing
- ✓ Research & development
- ✓ Nutrition

Hidden hunger is a micronutrient deficiency that affects over 3 billion individuals worldwide. Commercial food fortification is a sustainable and affordable solution that can be used to address this problem. **The Fortified extruded rice analogs** are a prime example of fortification being successfully done on a large scale. Comprised of rice flour from broken rice kernels, a nutrient premix and water, fortified rice analogues can help reduce the prevalence of deficiencies of folic acid and iron. Rice fortification is already mandatory in 6 countries around the world. Policy change is necessary to ensure widespread affordability and accessibility to rice extruded analogs.

Introduction

Hidden hunger, also known as micronutrient deficiencies, afflicts more than 3 billion individuals globally.[1] It is a form of undernutrition that occurs when intake and absorption of vitamins and minerals are too low to sustain good health and development.[2] Contributing factors include poor diet, increased micronutrient needs during certain life stages, and pre-existing health conditions. Commercial food fortification is a scalable, sustainable, and cost-effective technology that involves adding measured amounts of micronutrients to staple foods during processing to help consumers reach recommended nutrient levels. As one of the world's most widely consumed foods, rice plays a significant role in diets around the world. Milled rice represents the main source of energy and protein intake for 3 billion people globally.[3] Though it is a great source of energy, it is a poor source of micronutrients and has a low overall nutritional value beyond carbohydrates and protein. The popularity of rice makes it an ideal candidate to undergo fortification and presents an opportunity to fill the nutrient gap in rice-eating populations worldwide by increasing its nutritional value. White rice is one of the main consumed varieties. During milling, the bran layers that are rich in fat and micronutrients are removed which results in a high calorie product with a low nutritional value.[4] A wide variety of vitamins, minerals, and other nutrients such as amino acids and fibers can be added after milling to effectively address malnutrition. In 2018, the World Health Organization (WHO) published a guideline with evidence on how fortified rice consumption can increase vitamin and mineral intake.[5]

Indonesia has become one of the 17 most nutritionally concerning countries with widespread issues such as stunting, underweight, anemia, vitamin A, and iodine deficiencies. Rice plays an important role in Indonesian diets with 97.7% of Indonesians consuming rice daily but less than 50% of the population consuming the required amounts of vitamins and minerals particularly iron, calcium, and vitamins B_1, B_2, B_3, and B_9.[3]

While methods such as dusting and coating have been used to fortify rice, they pose a number of disadvantages. Coating uses entire kernels, which are typically more expensive than broken ones.[4] Both dusting and coating methods do not allow for a cooking process in which excess water is used as the nutrients would be washed away.[5] The use of a fortified extruded rice analog addresses these issues. Since evidence from developed countries showed that the health and academic performance of primary school children are improved through the introduction of school food and health programs, the Food and Nutrition Society (PERGIZI PANGAN) Indonesia, in collaboration with BRIA Indonesia and GIZ, conducted a study on fortified extruded rice analog production and its clinical impact on reducing micronutrient malnutrition in Indonesian school children, with promising results.

Response

DSM, a global leader in health and nutrition that has worked with organizations such as UNICEF and The Global Alliance for Improved Nutrition (GAIN) to fight hunger, has been a pioneer in developing a robust hot extrusion technology applicable to a variety of countries and rice varieties. Hot extrusion is the preferable method for rice fortification as it provides flexibility for modifying rice kernel properties and a product match to regular white rice.[4] The process has high capacity, uses broken kernels from harvests and can be done in a continuous manner in a few simple steps.[6] The broken rice kernels are ground to make rice flour and then mixed with water and nutrients of interest to form a dough. The dough is passed through an extruder to obtain rice kernels that are then blended with regular rice in a ratio of 0.5-2%.[7]

Several different disciplines were involved in designing a solution for hidden hunger, including nutritional analysis, food process engineering, and product development. Nutritional analysis was crucial to understand what the main nutrient deficiencies in the population are and to determine the optimal ratio of vitamins and minerals in the rice. Food process engineering was necessary to design the proper technology to manufacture extruded rice analogs (i.e., fortified kernels), as well as the knowledge necessary to understand how different conditions and processes (high heat, pressure, light, etc.) can affect the integrity of these nutrients and minerals. Lastly, product development was required to develop a nutrient blend formula that was stable and could be produced in other facilities.

The Food and Nutrition Society of Indonesia did a research study using DSM's premix formula which aimed to produce and supply fortified rice to school teenage girls and to evaluate the effects the consumption of this rice had on their health. The study was performed from March to June 2016, in Medan of North Sumatra Province, Indonesia. The number of subjects was 100 per intervention group. They were teenage girls between 14-18 years old who had symptoms of anemia. The control group (n=107) was given the non-fortified rice, while the intervention group (n=108) was given the fortified rice.[6] The micronutrients provided in the rice nutrient blend were iron, zinc, thiamin, folic acid, vitamin B_{12}, niacin, and vitamin A. The level of these nutrients was enough to fulfill more than 75% of the Recommended Dietary Allowance (RDA). The amount of fortified cooked rice was 450g per day (150g of fortified rice per meal), and the subjects were given fortified cooked rice six days a week for fifteen weeks. The biomarkers studied in this intervention were ferritin, hemoglobin, folic acid, vitamin A serum, and C-reactive protein (CRP). The fortified rice was produced by mixing the fortified kernels with the non-fortified ones in a ratio of 2:100 and was prepared at the boarding school kitchen.[8]

Evaluation of the effectiveness of the fortification technology was multifold, including shelf-life, processing parameters/conditions, consumer acceptance, and nutrient bioavailability (Figure 1). Storage stability depends on many factors, such as the oxidation of added vitamin A, packaging material, light exposure, and processing temperature. Method of rice preparation also has a significant impact on the fortification effectiveness. Two main factors affect the preparation process: washing and cooking stability. The lowest cooking losses are found

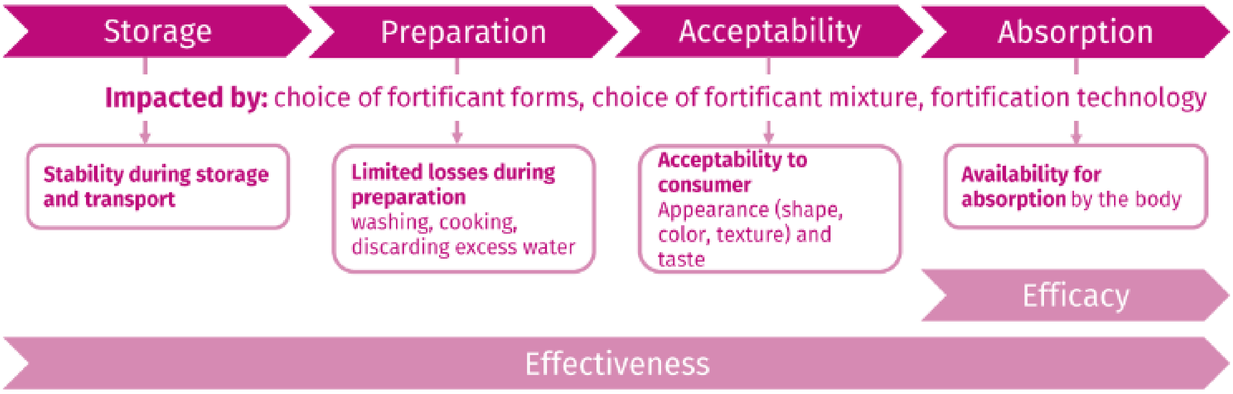

Figure 1. *Evaluation of the effectiveness of fortification technology (Reprinted with permission from Sight and Life).*

when rice absorbs all the water as compared to cooking in an excess of water.[9]

Extrusion based fortification technology has important advantages as compared to dusting and coating methods. They can lead to change in taste, color, and micronutrient loss.[4] However, the finished product obtained through extrusion has similar visual and organoleptic characteristics to non-fortified rice. This is crucial to ensure that consumers do not need to change their habits in order to consume this fortified rice. This grain also provides a stable matrix for added nutrients as they are retained even after rinsing or cooking. Some studies have found that the retention of fortified iron, folic acid, zinc, and vitamin B_{12} was 75-100% in fortified rice manufactured by the extrusion technology. Furthermore, hot extrusion is a cost-effective technology and can use broken kernels, reducing potential food waste.[10] It provides a lot of flexibility because the size, shape and color of any variety of rice can be fortified and can be tailored to address different deficiencies present in different populations. This flexibility is also beneficial to manufacturers, as it provides an opportunity to stand out by selling healthier products and reaching new consumers.[11, 12]

For the study in Indonesia, the fortified rice was produced by a local production facility, PT FITS Mandiri, and was packaged into aluminum foil packs that were stored in a temperature controlled room between 19-22 °C.

Results

The variables collected that determined the efficacy of the study included the socio-economic conditions of the subjects, body weight, body height, food intake, and nutrient levels. The mean age of the subjects was 16.1 years, mean weight was 49.4 kg and mean height was 151.5 cm. The delta between the endline and baseline of nutrient intake were calculated individually for the intervention and control groups.

The results indicated that the intake levels of hemoglobin, zinc, vitamin A and CRP did not vary significantly. It also showed that the consumption of this fortified rice reduced the prevalence of deficiencies of folic acid and iron.

Fortified rice can be a solution to hidden hunger, the results of this study have potential for being sustainable in this population and over time. As mentioned above, fortified rice through hot extrusion is a cost-effective, robust and accessible technology that can be scalable to different population sizes and nutritional needs. Each population might require a different set of nutrients and hot extruded fortified rice allows for the premix added to the kernels to be tailored to these needs.

DSM has partnered with different companies and entities in rice-producing countries like Singapore, India, Costa Rica and Thailand to share their technology. Through these partnerships DSM provides expertise and supports the set-up of local extrusion plants to produce fortified kernels. Thanks to these partnerships, this fortified rice can be manufactured in-situ and it does not depend on transportation, weather, and other factors.

Lessons learned

One of the challenges found in this study is that some of the individuals were not eating three meals a day before the study began which introduced a lot of variability in the baselines established for each micronutrient. Attendance of the subjects was also affected from the morning to evening meal due a number of reasons including the acceptability of meals and lack of side dishes provided by the kitchen. The duration of the study was also only limited to fifteen weeks as the fasting month of Ramadan coincided with the dates of the study.

Fortified extruded rice not only improves the health of malnourished populations but it allows to utilize the kernels that get broken during harvest. The rice flour used to manufacture these fortified kernels comes from broken grains that can make up to 25% of the total harvest.[6]

Next steps

More research needs to be done to evaluate the retention of different vitamins and minerals in fortified rice during cooking. Some preliminary research indicates that some vitamin A is lost during cooking depending on the fortification technique (hot and cold extrusion) and the cooking method. In addition, more information is needed to determine the bioavailability of these micronutrients after cooking.[13]

Based on this technology, DSM is also developing another 2 sets of products to tackle other deficiencies. The short-term goal consists of developing a high protein and high fiber fortified rice. In the long term, DSM plans to develop fortified rice lentils, fortified instant rice, fortified rice for RTE meals, and extruded rice puffs. This will increase the availability of fortified products in the market and hence reach different populations that might not consume rice on a daily basis. Furthermore, DSM also offers instant fortified rice flakes (to use in cereal drinks, breakfast cereal, or cereal bars) and instant fortified rice powder (to use in fortified soups or cereal drinks).[14]

Other approaches to fighting hidden hunger could be developing rice analogs using other abundant food staples. A study in Indonesia developed a rice extruded analog using cassava and tempeh flour through cold extrusion.[15] In addition, policy changes that ensure accessibility and affordability to these fortified products need to be made. Currently, rice fortification is mandatory in six US states and six countries; Costa Rica, Nicaragua, Panama, Papua New Guinea, Philippines and the Solomon Islands.[12, 16] In places like Bangladesh rice is fortified and available on open markets.[17] Other countries are in the process of implementing mandatory legislation for rice fortification, such as Peru, or carrying out pilot trials, such as in the Dominican Republic.[14]

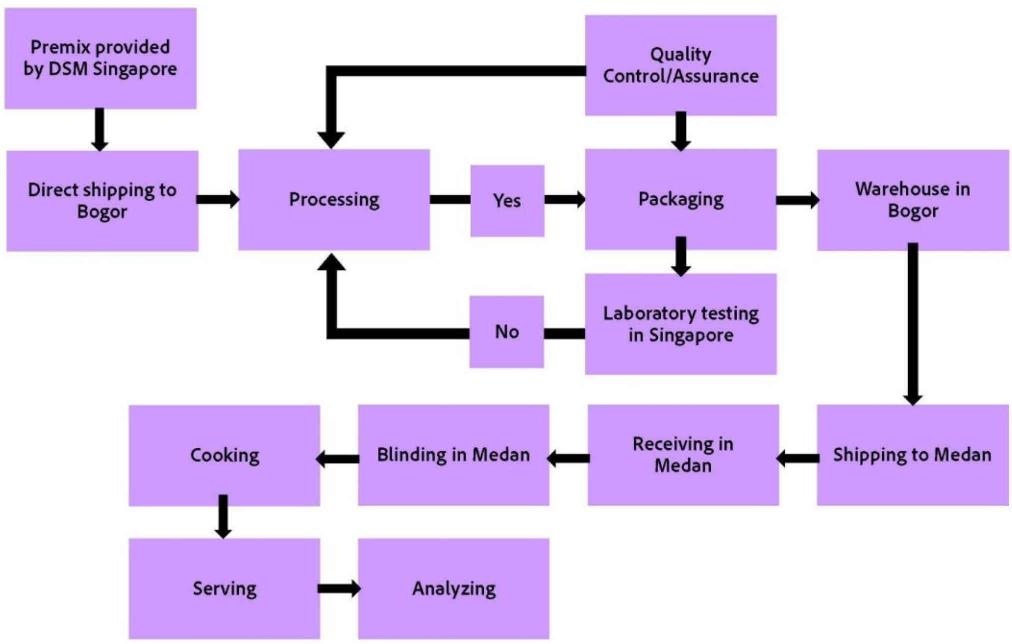

***Figure 2**. Schematic process of the fortified rice kernel production in Indonesia*

References

[1] Talking Nutrition Editors. DSM. New research signals global hidden hunger emergency. 2022.

[2] von Grebmer K, Saltzman A, Birol E, Wiesmann D, Prasai N, Yin S, et al. Global hunger index: The challenge of hidden hunger. 2014.

[3] Yadav S, Kumar V. Feeding the world while caring for the planet. Direct Seeded Rice Consortium . 2018 Dec;1(2):3–4.

[4] Steiger G, Müller-Fischer N, Cori H, Conde-Petit B. Fortification of rice: Technologies and nutrients. Ann N Y Acad Sci. 2014 Sep 1;1324(1):29–39.

[5] Guideline: Fortification of rice with vitamins and minerals as a public health strategy.

[6] Yoo J, Alavi S, Adhikari K, Haub MD, Aberle RA, Huber G. Rice-shaped extruded kernels: Physical, sensory, and nutritional properties. Int J Food Prop. 2013 Jan 1;16(2):301–21.

[7] DSM. Everything you need to know about fortified rice [Internet]. 2019. Available from: https://www.dsm.com/human-nutrition/en/talking-nutrition/everything-you-need-to-know-about-fortified-rice.html

[8] Hardinsyah, Briawan D, Budianto S, Hustina P, Ghifari N, Suhandono S. Final Report: Production and clinical impact study of micronutrients fortified rice for teen girls in islamic boarding school in Medan, Indonesia. 2016.

[9] World Health Organization. Guideline: Fortification of rice with vitamins and minerals as a public health strategy. 2018.

[10] Nateghi L, Gohari AS, Tabar MN, Alipour M. Analog rice: processing and nutrition value. Journal of Human, Health and Halal Metrics [Internet]. 2021;2(2):18–24. Available from: https://doi.org/10.30502/jhhhm.2021.300053.1038

[11] Yogeshwari R, Hemalatha G, Vanniarajan C, Saravanakumar S, Kavithapushpam A. Development of micronutrient fortified extruded rice analogues. Eur J Nutr Food Saf. 2018 Dec 5;9(1):1–11.

[12] DSM. The role of rice fortification in improving public health. 2018.

[13] Wieringa FT, Laillou A, Guyondet C, Jallier V, Moench-Pfanner R, Berger J. Stability and retention of micronutrients in fortified rice prepared using different cooking methods. Ann NY Acad Sci. 2014;

[14] Foing Y. Partnering with DSM to make products with purpose. 2020.

[15] Putri R, Mahanani T, Simatupang E, Rohmah K, Lestari I, Astuti W, et al. Synthesis of cassava analog rice fortified with protein tempe flour using cold extrusion method. The 9th Engineering International Conference. 2021;

[16] Food Fortification Initiative. Global Progress.

[17] Ahmed M. World Food Programme. Fortified rice to be available in open market sale in Dhaka North and Dhaka South city corporations. 2020.