Combating national malnutrition issues through staple food fortification

Executive summary

Shortages in adequate vitamin and mineral intake have led to a rising incidence of 'hidden hunger', a phenomenon caused by a chronic lack of essential micronutrients in a person's diet. Deficiencies in the vitamins and minerals essential for achieving good nutrition continue to plague countries across the globe, including developed nations, where it has been shown that it is possible to be both overweight and malnourished at the same time. Governments, organizations and non-governmental organizations (NGOs) worldwide now have an opportunity to address these deficiencies, working with food manufacturers to integrate essential micronutrients into staple food products through fortification. Micronutrient fortification of staple foods, such as wheat and maize flour, has even been shown to play a significant role in increasing productivity at work, and therefore stimulating the growth of a country's economy.[1] It also has the potential to help make hidden hunger a problem of the past, enabling millions of individuals worldwide to be healthier and able to thrive.

December 2018

HEALTH · NUTRITION · MATERIALS

DSM
BRIGHT SCIENCE. BRIGHTER LIVING.

Combating national malnutrition issues through staple food fortification

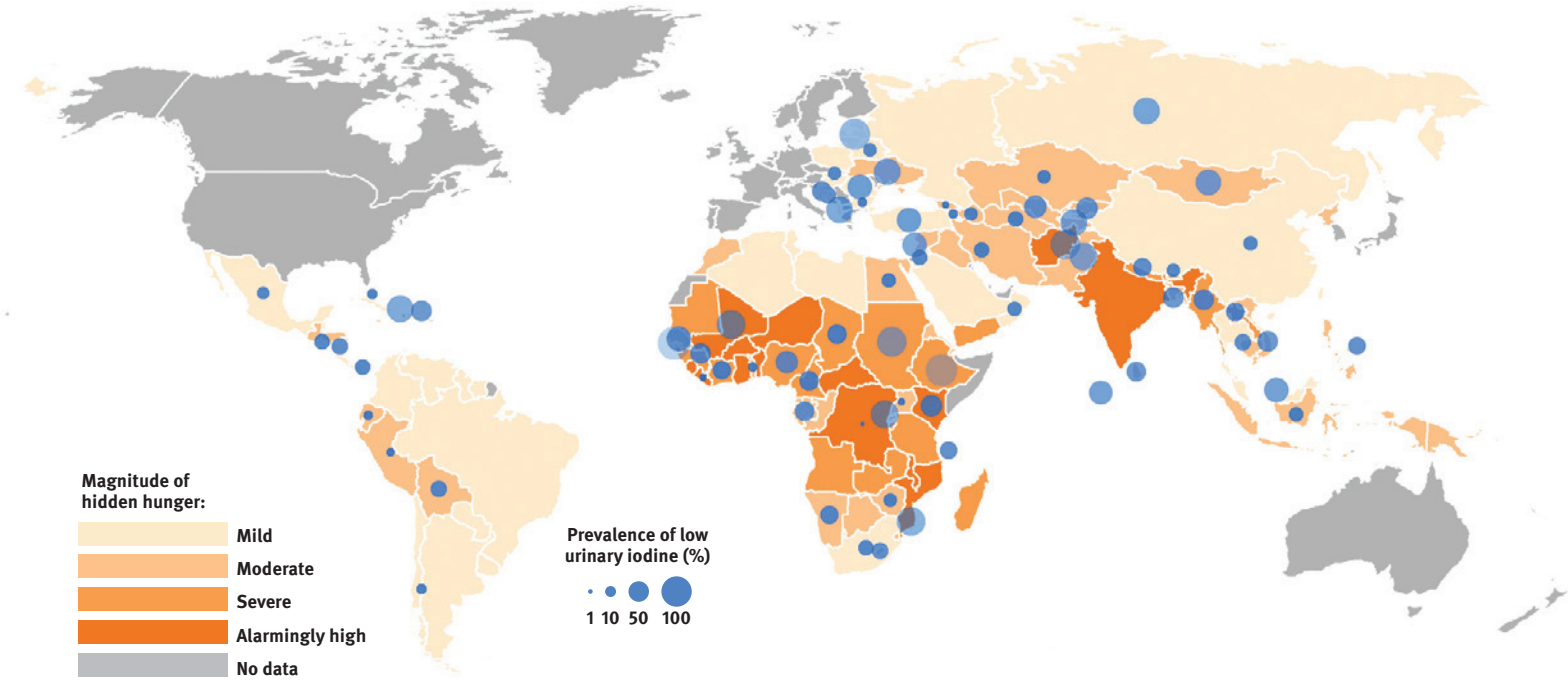
The cost of malnutrition

It is estimated that one third of the world's population is undernourished, caused by a physical or financial lack of access to a balanced, healthy and nutritious diet. Inadequate nutrition can have a major, long-lasting impact on human physical health and development, but also places a heavy burden on societies across the world. This can seriously challenge a country's economic growth.

What is hidden hunger?

Hidden hunger is a phenomenon where a diet is lacking in essential vitamins and minerals, causing the body to be malnourished. Hidden hunger is present in both developed and developing countries worldwide, and its prevalence reflects in part the rise in calorie-rich, yet nutrient-poor, diets that do not meet nutritional requirements.

Figure 1: Prevalence of hidden hunger worldwide[2]



People who do not consume a sufficient proportion of micronutrients, particularly *in utero* and as children, are more likely to face cognitive and physical difficulties for the rest of their lives. Conditions such as stunting, reflected by a failure to reach linear growth potential as a consequence of suboptimal nutritional intake, remain a major public health concern in a number of developing countries. It is estimated that 162 million children worldwide under five years of age showed stunted growth in 2012.[3] Such conditions can increase the risk of illness, but may also result in delayed mental and physical development, affecting school performance and productivity during the working lives of individuals.

Combating national malnutrition issues through staple food fortification

Figure 2: Global map of vitamin E status in healthy populations[4]

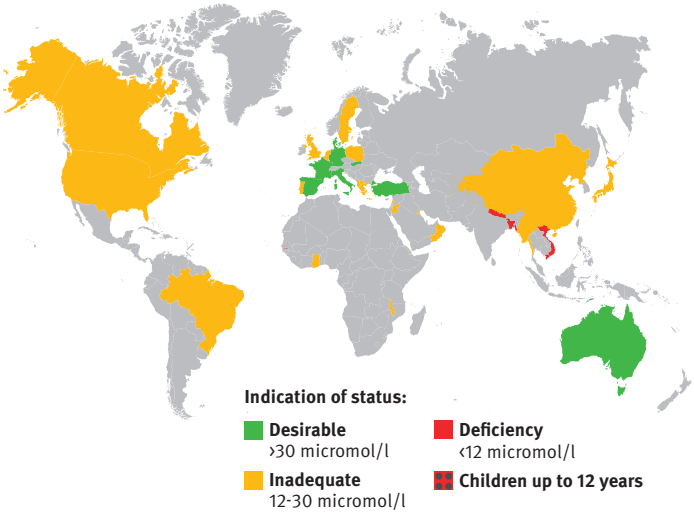
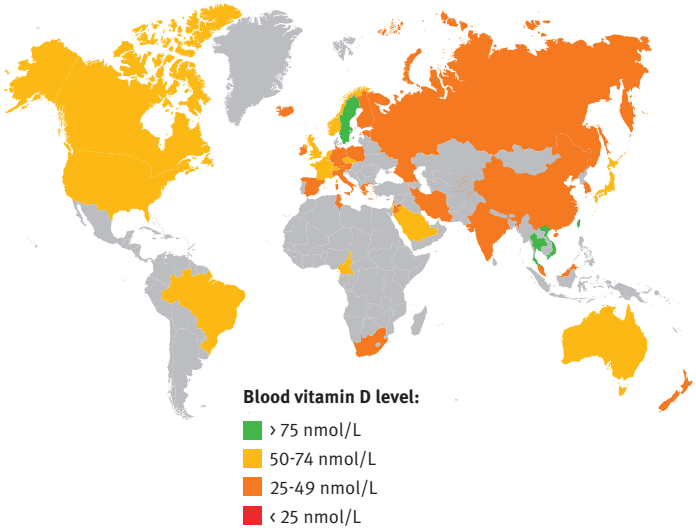


Figure 3: Global map of vitamin D deficiency in adults[5]



Combating national malnutrition issues through staple food fortification

Overweight and malnourished

Changes in global dietary habits now mean that malnutrition is no longer a problem that exclusively affects those in developing countries with limited access to food. Reports estimate that there are two billion people worldwide living with hidden hunger, which can occur even if a person is consuming a sufficient quantity of food.[6] In fact, hidden hunger can, and often does, arise in overweight or obese individuals in developed, westernized regions consuming diets that are high in calories, but poor in nutrients, and processed foods. The result is that it is now possible to be both malnourished and overweight at the same time. Indeed, Gross Domestic Product (GDP) growth no longer guarantees an improvement in nutritional status.

Vitamin A is essential for vision (particularly night vision), growth and development, immune function and for healthy male and female reproductive organs. Being deficient in vitamin A is a leading cause of blindness, and can contribute to high rates of childhood mortality and serious birth defects.[7]

Vitamin B12 is a water-soluble vitamin that plays an important role in the function of the brain and nervous system, as well as the formation of red blood cells. Humans are incapable of producing this vitamin, so must draw it from sources such as animal products, fortified food products and dietary supplements.[10]

Vitamin C is a water-souble antioxidant that is present in many fruits, vegetables and dietary supplements, and helps to support immunity and the regeneration of other antioxidants, such as vitamin E.[13] It can also help to achieve good cardiovascular health.[14] Severe vitamin C deficiencies can cause scurvy, which can cause bleeding gums and pain in the muscles and joints.

Folic acid is often recommended during pregnancy to prevent neural tube defects and support the health of red blood cells.[15] Deficiency can contribute to tiredness, irritability and appetite loss, while severe deficiencies can cause anemia and, if in pregnant women, can result in premature birth.[16]

Vitamin D, often known as the 'sunshine vitamin', is a fat-soluble essential nutrient, providing a number of health benefits. It is recognized for its role in calcium absorption, which helps to support bone health. Deficiencies can contribute to rickets in children and osteoporosis in adults.[8] Vitamin D also plays an important role in supporting immune function and cardiovascular health.[9]

Vitamin E is an essential fat-soluble antioxidant vitamin that is important in supporting heart health.[11] It helps to defend cell membranes from oxidative damage or inflammation, which can contribute to CVD.[12]

Iron performs a number of vital roles in the body, including the transportation of oxygen to body tissues and red blood cell regeneration. A shortfall of iron is one of the most common nutritional deficiencies in the world and can result in anemia, which leads to fatigue, shortness of breath and weakness.[17]

Why are micronutrients important?

The vitamins and minerals found in nutrient-rich foods play an important role in our health and wellbeing. Deficiencies of micronutrients in the diet are linked to a range of health concerns, as well as an increased risk of chronic diseases, such as cardiovascular disease (CVD), diabetes and obesity.

Aside from helping to improve the physical and mental health and development of individuals, good nutrition is also considered a key trigger in ending the ongoing vicious cycle of poverty that traps millions of people in societies across the globe. The 2008 Copenhagen Consensus, a project that brought together a panel of world-leading economists, concluded that improving nutrition was one of the best, most cost-effective development investments to address the major challenges facing the planet today.[18] Their forecasts and calculations suggested that:

- Spending US$ 60 million a year on micronutrient provision could yield benefits in terms of improved health, lower mortality and increased income opportunities worth US$ 1 billion
- An annual investment of US$ 19 million in food fortification could bring US$ 570 million in similar benefits[19]

Investing in good nutrition to address shortfalls in micronutrient intake clearly presents a significant opportunity to improve health and wellbeing, optimize development potential, and support the economic stability and growth of countries worldwide.

Combating national malnutrition issues through staple food fortification

What is staple food fortification?

Fortification is one of the most safe, effective and affordable tools to enhance the nutritional value of staple food products such as wheat, maize (corn), rice, vegetable oil and sugar. This process involves adding or replacing essential vitamins and minerals that may have been lost during processing, and has become well recognized for its benefits to public health. In many countries, staple food fortification is now mandatory, a movement that started to gain traction in the 1970s and took off in the early 2000s as more and more countries integrated it into their nutrition strategies. One of the earliest regions to adopt was the Middle East where, in 1978, Saudi Arabia was amongst the first countries to implement wheat flour fortification.[20] By 1996, Oman had also rolled out mandatory national-scale flour fortification, and several other countries in the region, including Jordan and Iran, followed shortly after.[21] To date, it is estimated that 94 countries across the globe have either mandatory or voluntary wheat flour fortification.[22]

Success story: Indonesia

Based on evidence of widespread micronutrient deficiencies and the popularity of wheat flour products in the country, the Indonesian Ministry of Health made the fortification of all wheat flour milled or imported into Indonesia mandatory in 1998. Following an extensive consultation with global and national experts, legal and regulatory foundations were later laid out in the Decree of the Ministry of Industry and Trade on the Compulsory Application of Indonesian National Standard (SNI).

Updated in 2009, this framework defines 16 required product quality parameters for wheat flour. High quality fortification programs have been shown to be safe, proven and cost-effective methods of improving public health, but poor-quality programs can be expensive and ineffective. This dedication to quality across an entire program has helped to increase the success of fortification in the country.[23]

Combating national malnutrition issues through staple food fortification

What makes it so successful?

Return on investment

The impressive uptake of staple food fortification can be attributed to a number of factors: it is relatively easy to implement and it is cost-effective, meaning that governments and food manufacturers can quickly see tangible results that help to justify the initial investment in machinery. Staple food fortification contributes significantly to improving the nutritional status and public health of an entire country, saving millions on healthcare costs each year, and enabling more of the population to be in employment and contribute to the economy. This is as a result of a reduced incidence of chronic illness and cognitive and physical stunting which, in turn, contributes to improved school and work performance and productivity. These factors can impact a person's livelihood and well-being for the rest of their lives, proving that taking what seems like a relatively small step, can provide a huge social return on investment (ROI) for a nation.

In addition to social ROI, staple food fortification has also been proven to have economic implications, too. The 2012 Copenhagen Consensus found that long-term investments to fight hunger and malnutrition, such as market innovations to tackle hunger and bundled interventions to reduce micronutrient malnutrition and the prevalence of stunting, could provide a ROI of up to 30:1.[24] Similarly, if the aim to lower chronic child malnutrition by 40% by the year 2030 is achieved, it is estimated to provide a ROI of 45:1.[25]

Acceptance

The widespread acceptance of staple food fortification can be owed to the fact it can be implemented without changing the dietary patterns of a population. Nor does it require conscious engagement or compliance from individuals – advances in technology mean that it is possible to fortify products, such as rice or flour, without any impact on sensory characteristics, like appearance and taste. As a result, populations can continue to eat the way they have always eaten, which helps to not only tackle challenges in consumer attitudes, but is also very important in developing countries or regions, where there is little freedom of choice over the food products available.

It is clear that staple food fortification has the potential to play an important role in helping to improve the nutritional status of the global population. However, it is vital that governments and the food industry worldwide play their part in bringing about this change. An important factor in facilitating the success of food fortification initiatives is to ensure that mandated staple foods are properly monitored and enforced by governments, and complied with by the food industry. Countries that do not engage with such initiatives risk a significant missed opportunity, as well as a loss of the initial investment made if they fail to maintain the running of fortification programs. Perhaps more importantly, those who are in need will not be able to receive the benefits that staple food fortification can provide.

Combating national malnutrition issues through staple food fortification

Types of fortification

Flour fortification

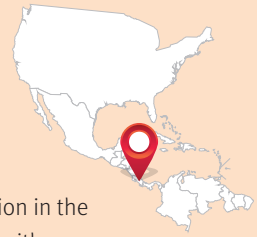
Flour – wheat and maize, primarily – is one of the most widely distributed and consumed staple food products. In fact, more than 600 million metric tons of wheat and maize flours are milled annually, and consumed as noodles, breads, pasta, and other flour products worldwide.[26] Wheat and maize flour are easily fortified with a wide range of micronutrients, meaning that there is huge potential for flour products to substantially improve global public health.[27] The World Health Organization (WHO) and NGOs such as Nutrition International (NI).[28] In fact, there are now 87 countries worldwide where it is mandatory to fortify at least one industrially milled cereal grain, such as maize or wheat. Of these, 86 countries fortify wheat flour alone, or in combination with other grains, suggesting that there is significant opportunity for the food industry and governments to address global malnutrition with this staple food product.[29]

Micronutrients can be added singly or as a premix to wheat or maize flour, and it is vital that the flour is well mixed so that the added nutrients are distributed uniformly throughout the product. This is achieved by adding the nutrients at a rate compatible with the flow of flour along a conveyor belt, using adjustable feeders, and can also be added when flours from different batches converge. To avoid separation of the nutrients from the grain, it is important to make sure that the particle size and weight of these micronutrients are the same, or similar, as that of the flour product.

Success story: Jordan

Mandatory wheat flour fortification was introduced in Jordan in 2002, after the country's first nationally representative survey on micronutrient status revealed that low micronutrient intake was a major public health concern.[30] Flour was initially fortified with iron and folic acid, although fortification with zinc, niacin and vitamins A, B and D followed shortly after. A follow up survey in 2010 showed that the roll-out of the program in Jordan had been a huge success, with wheat flour products now routinely fortified with a wide range of essential vitamins and minerals.[31] Continued efforts are essential to support and widen the scope of fortification initiatives, to improve public health in Jordan.

Success story: Costa Rica



Costa Rica is leading the way for food fortification across Latin America and the wider world, as the region with the highest number of staple foods legally required to be fortified. The first instances of food fortification began in 1996 and mandatory rice fortification was introduced in 2003, led by the higher consumption in the region. In fact, 99% of the population are estimated to eat rice – with an average intake of 150g a day. Fortified with vitamins B1, B12, and E, folic acid, niacin, zinc and selenium, rice fortification has offered a wealth of benefits for the country and the Ministry of Health declared it to be free of anemia due to the fortification efforts.[32]

Combating national malnutrition issues through staple food fortification

Rice fortification

Rice is the primary staple food crop of approximately half of the global population.[33] It provides more than a fifth of the world's food calories and is a major food product, especially in Asia, where individuals consume in some cases up to 150kg of milled rice per year. However, most of the nutritional value of rice is lost during milling of the kernels, meaning that it is not a rich source of the essential vitamins and minerals. In fact, hidden hunger is widespread in most countries that consume high levels of rice; even if its residents are consuming enough to address physical hunger requirements.[34]

There is clearly a big opportunity for food manufacturers to address these micronutrient deficiencies through rice fortification, particularly in countries where rice is a major staple food product, or where wheat and maize flour fortification programs are less accessible. There are a number of methods that can help boost the nutritional quality of rice. Extrusion, which is the most effective technique, embeds micronutrients into the rice kernel, meaning that these important vitamins and minerals are protected from external influences during washing and cooking. This process also maintains the look, feel, taste and behavior of traditional rice kernels, minimizing any impact on sensory experience.

Alternatively, rice fortification can be achieved by 'dusting' the kernel with a micronutrient powder that adheres to the grains, or by the spraying of the surface of ordinary rice grains with a vitamin and mineral mix to form a protective coating.[35] The challenge with these techniques, however, is that the nutrients added to the rice kernels may be lost during washing. Furthermore, in some countries such as the US, questions have been raised as to whether the substances used for wash-resistant coatings are suitable for use on food products. For this reason, extrusion is typically the preferred choice for food manufacturers who choose to fortify their rice products.

Sugar fortification

Although diets high in sugar have come into question over their impact on human health, sugar continues to be a widely consumed staple food for millions of individuals around the world. In countries that have mandated its fortification, sugar has proven to be one of the most cost-effective and safe food-based interventions to combat and control deficiencies, particularly in vitamin A. Conventional sugar fortification technology uses vitamin A beadlets that adhere to sugar crystals with the help of oil.

Vegetable oils and margarine

Oils and fats are key components of human diets across the world and provide energy and essential fatty acids that are important for optimal growth and development. The consumption of vegetable oils, such as soy, palm and sunflower, is high throughout the world and continues to increase, particularly in developing countries and low socio-economic groups. These oils can also be fortified with fat-soluble vitamins to increase their nutritional offering, and become a richer source of vitamins A, D and E.

Instant noodles

While not a traditional staple food product, the popularity of instant noodles has soared in recent decades due to their convenience and affordability. This is particularly true in some Asian and African countries such as Indonesia and Nigeria, respectively, and they are now available in over 80 countries. However, instant noodles have poor nutritional value and often only offer 'empty calories' that fulfill physical hunger needs, without addressing micronutrient requirements. The fortification of instant noodles is an important step towards improving public health through good nutrition, without the need for significant changes to human diet or national dietary patterns. Numerous micronutrients can be incorporated to add value to this product, including vitamins A, C, D and E, folic acid, niacin and minerals iron, zinc and calcium, via custom-made micronutrient blends.

Bouillon cubes

Bouillon cubes, which can be used in soups and as a source of salt and spice in some food products, are also of special importance, particularly in Western Africa. They are inexpensive to produce and are affordable for populations with low incomes. They can also be easily fortified to become an accessible source of vitamin A, B vitamins, iron and zinc.

Combating national malnutrition issues through staple food fortification

Conclusion

Hidden hunger continues to be a major public health concern across the globe, and can have a devastating long-term impact on the health, wellbeing and development of individuals, societies and nations worldwide. Advances in fortification technology now mean that it is easier than ever for food manufacturers and millers across the globe to combat malnutrition in developing and developed countries, without impacting dietary patterns or the sensory characteristics of foods. Improving the population's nutritional status through staple food fortification can help to facilitate a huge social and financial ROI to support the world's economic growth and development, as well as the work of NGOs and organizations in both the private and public sector. It can also play a huge part in addressing the challenges presented by poor nutrition, such as cognitive and physical stunting, to improve productivity and public health.

Why DSM?

DSM is the world's leading manufacturer of ingredients for health and nutrition. It has been the pioneering industry partner in the establishment of staple food fortification and remains a trusted leader in this area, through its Nutrition Improvement Solutions. DSM offers a broad range of high quality and affordable premixes to add to fortified staple food. These can be tailored to meet unique requirements and challenges, allowing DSM to fully support customers' needs and ambitions and provide key advice and solutions.

Quality for Life®

For DSM, quality is a way of life. Quality for Life™ symbolizes quality, reliability and traceability. This means that our customers are getting the best ingredients, knowing the source on which they depend. Quality for Life™ means sustainability. It is our commitment to our environment, consumers, our business partners, our people and the regulatory framework that governs our operations.

Do you want to update your staple food fortification program, or start a new one? Contact DSM on ***nutrition.improvement@dsm.com*** *for an in-depth discussion.*

Combating national malnutrition issues through staple food fortification

Notes

Combating national malnutrition issues through staple food fortification

Notes

Combating national malnutrition issues through staple food fortification

References

1. UNICEF, *Undernutrition contributes to nearly half of all deaths in children under 5 and is widespread in Asia and Africa*, [website], 2017, https://data.unicef.org/topic/nutrition/malnutrition/.
2. S. Muthayya et al., 'The global hidden hunger indices and maps: an advocacy tool for action', *PLoS ONE*, vol. 8, no. 6, p. 1-12.
3. Op. cit. (UNICEF).
4. P. Szabolcs et al., 'A systematic review of global alpha-tocopherol status as assessed by nutritional intake levels and blood serum concentrations', *International Journal for vitamin and nutrition research*, vol. 14, no. 1, 2016, p. 1-21.
5. International Osteoporosis Foundation, *Vitamin D status around the world*, [website], 2017 https://www.iofbonehealth.org/facts-and-statistics/vitamin-d-studies-map.
6. World Health Organization, *WHO and FAO announce Second International Conference on Nutrition (ICN2)*, [website], 2014, http://www.who.int/nutrition/topics/WHO_FAO_ICN2_videos_hiddenhunger/en/.
7. A. Sommer, 'Vitamin A Deficiency and Its Consequences: A Field Guide to Detection and Control. Geneva': *World Health Organization*, 1995.
8. C. R. Paterson, 'Vitamin D deficiency, rickets and osteomalacia', *Reference Module in Biomedical sciences*, 2017.
9. Vitamin D council, *What is vitamin D?*, [website], 2011 https://www.vitamindcouncil.org/about-vitamin-d/what-is-vitamin-d/.
10. NHS Choices, *B vitamins and folic acid*, [website], 2014, http://www.nhs.uk/Conditions/vitamins-minerals/Pages/Vitamin-B.aspx.
11. U.S. Institute of Medicine. '*Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids*', [website], https://www. nap.edu/catalog/9810/dietary-reference-intakes-for-vitaminc-vitamin-e-selenium-and-carotenoids.
12. E. B. Rimm et al., Antioxidants for vascular disease, *Med Clin North Am*, 2000, vol. 84, issue 1, p. 239-249.
13. Op. cit. (U.S. Institute of Medicine).
14. A. W. Ashor et al., 'Effect of vitamin C on endothelial function in health and disease: a systematic review and meta-analysis of randomised controlled trials'. *Atherosclerosis Journal*, 2014, vol. 235, no. 1, p. 9-20.
15. K. Bibbins-Domingo et al., 'Folic Acid Supplementation for the Prevention of Neural Tube Defects', *JAMA*, 2017, vol. 317, no. 2, p. 183.
16. Ibid.
17. CDC Centers for Disease Control and Prevention, *Recommendations to Prevent and Control Iron Deficiency in the United States*, Morbidity and Mortality Weekly Report, [website], 1998, https://www.cdc.gov/mmwr/preview/mmwrhtml/00051880.html.
18. Copenhagen Consensus, *2008, Copenhagen Consensus*, [website], 2008, http://www.copenhagenconsensus.com/copenhagen-consensus-ii.
19. Ibid.
20. Food Fortification Initiative, *Middle East*, [website], 2016 http://ffinetwork.org/regional_activity/middle_east.php.
21. Ibid.
22. World Health Organization, Training workshop: Best practices of wheat flour fortification, [website], 2017, http://www.who.int/nutrition/events/2017-training-workshop-wheatflour-fortification-18to19Oct/en/.
23. UNICEF, FFI., 'Monitoring of flour fortification: The case of Indonesia.', [website], 2014, http://www.ffinetwork.org/monitor/Documents/IndonesiaCS.pdf.
24. Copenhagen Consensus, *2012, Copenhagen Consensus*, [website], 2012, http://www.copenhagenconsensus.com/copenhagen-consensus-iii.
25. Copenhagen Consensus, *Post-2015 Consensus*, [website], 2015 http://www.copenhagenconsensus.com/post-2015-consensus.
26. WHO, FAO, UNICEF, GAIN, MI, & FFI., *Recommendations on wheat and maize flour fortification. Meeting Report: Interim Consensus Statement. Geneva*, World Health Organization, 2009, [website], http://www.who.int/nutrition/publications/micronutrients/wheat_maize_fort.pdf.
27. Food Fortification Initiative, *Global Progress*, [website], 2017, http://ffinetwork.org/global_progress/index.php.
28. WHO/FFI, *Joint WHO/Flour Fortification Initiative Harmonization workshop for wheat and maize flour fortification*, [website], 2012 http://applications.emro.who.int/docs/IC_Meet_Rep_2012_EN_14767.pdf.
29. Op. cit. (Food Fortification Initiative, *Global Progress*).
30. Ibid.
31. Jordan Ministry of Health, *National Micronutrients Survey Jordan 2010*, [website], http://www.gainhealth.org/wp-content/uploads/2014/05/56.-Jordan-Micronutrient-Survey-Report.pdf.
32. L. Tascan et al., Rice Fortification in Costa Rica, *Sight and Life*, 2017.
33. World Health Organization, *Fortification of Rice*, [website], 2017, http://www.who.int/elena/titles/rice_fortification/en/.
34. Ibid.
35. Ibid.