MMS Bulletin #119

Kampf gegen Mangel- und Unterernährung: Schlüssel zur Gesundheit in Entwicklungsländern

Fighting micronutrient malnutrition

Biofortification: A strategy to prevent micronutrient malnutrition

Von Ines Egli

The lack of micronutrient is one of the causes of malnutrition affecting many people in the developing world. There are many methods to increase the micronutrient quality of food. One of them is biofortification – a method to increase the nutritional value of crops.

Nigeria © Kate Holt/IRIN

The control of micronutrient (vitamin and mineral) malnutrition is an essential part of the overall effort to fight malnutrition. It is estimated that circa on third of the world's population are affected by deficiencies of one or several micronutrients. The most prevalent deficiencies are: anemia and iron deficiency affecting 1.6 billion people; iodine deficiency with 1.9 billion people at risk; and vitamin A deficiency affecting 190 million children under 5 years of age (WHO 2004; WHO 2008; WHO 2009). Deficiencies of zinc, folate, and B-vitamins are also prevalent but the extent is less well known. Low intakes and/or low bioavailability of micronutrients from monotonous plant based diets lead to micronutrient deficiencies often in the most vulnerable population groups such as women and young children. Micronutrient malnutrition causes reduced physical and cognitive development of children and increased morbidity and mortality in children and adults.

Control and prevention strategies

Strategies to prevent and control micronutrient malnutrition aim at increasing the micronutrient intake by dietary diversification, supplementation, fortification and biofortification. These approaches should be regarded as complementary with their relative importance depending on local conditions and specific requirements.

Dietary diversification aims at adding micronutrient dense foods, such as animal source foods, fruits and vegetables to diets based on staple food crops. The major constraints to dietary diversification are the availability and accessibility of micronutrient dense foods, especially in poorer settings as well as the need for behavior change and education.

Supplementation is the provision of relative large doses of micronutrients in form of pills or syrup to treat or prevent deficiencies. The most common supplementation programs include the provision of iron and folate to pregnant women and vitamin A for young children. Expensive supply and poor compliance are the major limitations of this strategy.

Fortification of foods with micronutrients is a preventive strategy which has been successfully used in many countries including well known programs such as salt fortification with iodine and wheat flour fortification with iron and folate. Guidelines to plan and implement efficient programs are available (WHO and FAO 2006). A major drawback of food fortification is that rural populations with limited access to processed foods can often not be reached. For these populations living predominantly on staple food crops biofortification is a promising approach.

Biofortification is the process of increasing the level and/or bioavailability of essential nutrients in edible parts of crops by conventional plant breeding or transgenic techniques. Conventional breeding has been the primary approach to enhance staple food crops with iron, zinc and provitamin A carotenoids. Rice, wheat, maize, pearl millet, the common bean, sweet potato and cassava are the main targeted crops of HarvestPlus, the CGIAR's (Consultative Group on International Agricultural Research) Biofortification Challenge program (Pfeiffer and McClafferty 2007; Bouis and Welch 2010). Three prerequisites have been identified to make biofortification successful: i) a biofortified crop must be high yielding and profitable to the farmer; ii) the biofortified crop must be shown to be efficacious and effective reducing micronutrient malnutrition in target populations, and iii) the biofortified crop must be acceptable to farmers and consumers in target regions (Hotz and McClafferty 2007).

For biofortified crops to be efficacious and effective, not only the enhanced concentration of the micronutrients in the edible part of the crop is important, but also the bioavailability of the micronutrients. In addition, the effect of food processing and preparation on micronutrient concentration and bioavailability needs to be considered. HarvestPlus has set target levels for iron, zinc and provitamin A carotenoids in crops taking processing and bioavailability aspects into account. The target levels would be expected to provide 25-50% of the Estimated Average Requirement (EAR) of the specific micronutrients (Hotz and McClafferty 2007; Bouis and Welch 2010).

Efficacy trials with biofortified food

Several studies evaluating the efficacy of biofortified crops have been completed or are currently being conducted. Iron biofortified rice was shown to marginally improve the iron status of non-anemic women in the Philippines (Haas, Beard et al. 2005). The intervention group received high iron rice, the control group regular rice over a period of 9 months. There was no significant increase in iron status parameters in the intervention group, except in a sub group of non-anemic women iron stores increased. These results raise the question of the usefulness of rice as a vehicle for iron biofortification when using conventional breeding. Using genetic engineering, the iron content in rice endosperm was increased circa 6-fold, reaching nutritionally relevant levels (Wirth, Poletti et al. 2009). The acceptance of such crops however would be expected to be more difficult to achieve in the population. Beans have a far higher iron content than rice which can be doubled by traditional plant breeding (Beebe, Gonzalez et al. 2000). The major drawback of beans is the low iron bioavailability due to the relatively high content of the inhibitors phytic acid and polyphenols. Iron absorption around 2% has been reported from single meal isotope studies (Donangelo, Woodhouse et al. 2003; Beiseigel, Hunt et al. 2007) and it has been shown that both, phytic acid and polyphenols contribute to the reduced absorption (Petry, Egli et al. 2010). Thus, to achieve high amounts of iron absorbed from biofortified beans, breeding should also focus on reducing phytic acid and polyphenol content. Efficacy trials with biofortified beans are ongoing; one has just been completed in school children in Mexico, one in reproductive age women is to be started in Rwanda (personal communication).

A recent forecast estimates that biofortification is more cost-effective than supplementation or fortification in reducing the burden of micronutrient malnutrition, especially in Asia (Meenakshi, Johnson et al. 2010).

**Ines Egli is a senior scientist and lecturer at the Institute of Food, Nutrition and Health, ETH Zurich. Contact: ines.egli@ilw.agrl.ethz.ch*

References

- Beebe, S., A. V. Gonzalez, et al. (2000). "Research on trace minerals in the common bean." Food and Nutrition Bulletin 21(4): 387-391.
- Beiseigel, J. M., J. R. Hunt, et al. (2007). "Iron bioavailability from maize and beans: a comparison of human measurements with Caco-2 cell and algorithm predictions." American Journal of Clinical Nutrition 86(2): 388-396.
- Bouis, H. E. and R. M. Welch (2010). "Biofortification-A Sustainable Agricultural Strategy for Reducing Micronutrient Malnutrition in the Global South." Crop Science 50(2): S20-S32.
- Donangelo, C. M., L. R. Woodhouse, et al. (2003). "Iron and zinc absorption from two bean (Phaseolus vulgaris L.) genotypes in young women." Journal of Agricultural and Food Chemistry 51(17): 5137-5143.
- Haas, J. D., J. L. Beard, et al. (2005). "Iron-biofortified rice improves the iron stores of nonanemic Filipino women." J Nutr 135(12): 2823-2830.
- Hotz, C. and B. McClafferty (2007). "From harvest to health: Challenges for developing biofortified staple foods and determining their impact on micronutrient status." Food and Nutrition Bulletin 28(2): S271-S279.
- Meenakshi, J. V., N. L. Johnson, et al. (2010). "How Cost-Effective is Biofortification in Combating Micronutrient Malnutrition? An Ex ante Assessment." World Development 38(1): 64-75.
- Petry, N., I. Egli, et al. (2010). "Polyphenols and phytic acid contribute to the low iron bioavailability from common beans in young women." J Nutr 140(11): 1977-1982.

- Pfeiffer, W. H. and B. McClafferty (2007). "HarvestPlus: Breeding crops for better nutrition." Crop Science 47: S88-S105.
- WHO (2004). Iodine status worldwide; WHO Global Database on Iodine Deficiency. Geneva, World Health Organization.
- WHO (2008). Worldwide prevalence of anamia 1993-2005. Geneva, World Health Organization.
- WHO (2009). Global prevalence o f vitamin A deficiency in populations at risk 1995-2005: WHO global database on vitamin A deficiency. Geneva, World Health Organization.http://www.who.int/vmnis/vitamina/prevalence/en/
- WHO and FAO (2006). Guidelines on food fortification with micronutrients. Geneva, World Health Organization. http://www.who.int/nutrition/publications/guide_food_fortification_micronutrients.pdf
- Wirth, J., S. Poletti, et al. (2009). "Rice endosperm iron biofortification by targeted and synergistic action of nicotianamine synthase and ferritin." Plant Biotechnology Journal 7(7): 631-644.

Kontakt

Deutschschweiz
Medicus Mundi Schweiz
Murbacherstrasse 34
CH-4056 Basel
Tel. +41 61 383 18 10
info@medicusmundi.ch

Suisse romande
Medicus Mundi Suisse
Rue de Varembé 1
CH-1202 Genève
Tél. +41 22 920 08 08
contact@medicusmundi.ch

Bankverbindung
Basler Kantonalbank, Aeschen, 4002 Basel
Medicus Mundi Schweiz, 4056 Basel
IBAN: CH40 0077 0016 0516 9903 5
BIC: BKBBCHBBXXX