

Is Fortification or Bio Fortification of Staple Food Crops will Offer a Simple Solution to Complex Nutritional Disorder in Developing Countries?

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Abstract

Large segment of global populations, especially in developing countries is currently at risk from one or more micronutrient deficiency, so called malnutrition. This could be due to our current food systems are fail to provide enough balanced dietary nutrients to meet all the nutritional requirements of every individual, especially resource-poor women and children in the developing countries. A variety of interventions have been used to address micronutrient malnutrition so far such as pharmaceutical supplementation, industrial fortifications and dietary diversification. However, success of supplementation and fortification in developing countries remains challenges due to poor infrastructure, delivery system, more often it need sustained investment year-after-year. Of course dietary diversity is an immediate issue of diverse food affordability since a sharp increase in food prices will have a large impact on rural-poor households' who's represent the most segment of malnourished population. Researchers now focusing an food based intervention so called biofortification (developing a cultivars with elevated micronutrients in their edible parts through convetional breeding or biotechnology) is found to be sustainable intervention, even if external support fails, biofortification will continue to combat multiple micronutrient deficiency simultaneously generation after generations. Though this strategy is not an Einstein idea but it was a pessimistic view for longtime among the community, however, with the advent of modern and advanced technology we deliberately believes it can be made successful in optimistic way by transforming the dynamic results into reality. Therefore, present view and optimism are more towards the biofortification of staples for better human nutrition to acieve appropriate nutrient level in the biofortified cultivars and further research is required to upscale at the global level to prove as an effective strategy.

Keywords: Fortification; Dietary

Introduction

Good health depends on good nutrition. Good nutrition, in turn, depends on sustainable agriculture to provide the adequate foods (such as cereals, pulses, vegetables, fruit, meat, fish, dairy products) for a balanced diet that meets our daily requirement of energy, protein, vitamins and minerals with adequate healthcare practices. During the mid-last century (1960-1970), when the threat of famine troubled the policymakers in developing countries and aided major investments in the green revolution, with an understanding that malnutrition is a broader problem than just insufficient intake of dietary energy and protein, so-called undernourishment but that it also encompasses two other dimensions, namely micronutrient deficiencies and overweight/obesity [1]. The challenge is, therefore, now often referred to as the triple burden of malnutrition [2]. Today, over three billion people throughout the world are suffering with micronutrient malnutrition and the numbers are still increasing [3,4]. The main reason is that deficiencies usually occur when the regular diet deficit diversity or is overly dependent on a single staple food, as is the case with monotonous cereal or pulse based diets (particularly in India) the latter become very rarely consumed by rural poor. Situations of food insecurity have ever been challenging in most developing countries like India and Africa, where populations don't have enough to eat, will also inevitably lead to micronutrient deficiency in addition to food insecurity as marginal and low fertile land brought into cultivations. Processing of plant based foods involves loss of mineral nutrients is a well knows fact by several research literatures [5]. For instance, consumption of polished refined cereal grains is missing fiber and key nutrients that their whole-grain counterparts retain, thus, it creates diabetes in countries like India- highest diabetic patients in the world (51 million) and this is anticipated to increase to 87 million by the year 2030 [6,7]. To overcome such losses, foods are enriched with nutrients by various biological or mechanical methods, so called food fortification. Other staple foods are

fortified by governments and other governance bodies (NGOs), with the object of overcoming endemic nutritional diseases (disorder) as a prophylactic measure. Manufactured consumer goods are also fortified with nutrients, either with the object of ensuring the nutritional adequacy of the product or to achieve better sales in the competitive market, as supermarkets are growing faster than agriculture at every kilometer in urban areas, however such methods are still under dispute.

In general, all agricultural produce are processed before they can be used as foods. For instance, Cereals and pulses are mostly subjected to milling and polishing before it consumption, similarly, milk is subjected to sequential processing (from pasteurization to homogenize through concentrated) and fruits, if they are to be processed, then its gets pulped, pasteurized, or concentrated with preservatives. On the other hand, meat and meat products have also been subjected to heat-processing for making processed products. During these processing stages, some portion of the nutrients are destroyed or otherwise lost from the original material (eg. Most grains have its nutritive value in aleurone layer or seed coat so called 'brans' in case of cereals) [8]. It is well known that some nutrient loss is inevitable where the raw foods cannot be consumed or preserved as such but there should be limit for these losses and so far not measured such losses to draw a threshold

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level. Thus, to overcome these problems, the term enrichment has been used to signify adding the nutrients back to the processed food that are lost during the processing, in such a way that the most nutritional value corresponds to that of the unprocessed food grains [9,10]. At the same time, to tackle certain endemic nutritional diseases which are prevalent in the developing countries like India there is urgency to increase the nutritional quality of staple foods such as cereals, pulses, millet and legumes and, besides the government's program of providing nutritional ingredients by using staple foods as the medium, if any. Fortification is also the term used when nutrients are added to new types of foods to make them resemble their natural counterparts. For example, the image to imitate when making synthetic soft drinks is lemon or orange juice, for vegetable milks it is cow milk, and for textured vegetable proteins it is meat or meat products. Therefore the terms enrichment and fortification or nitrification are often used interchangeably according to their expedient.

Fortification of staple foods is need of the hour

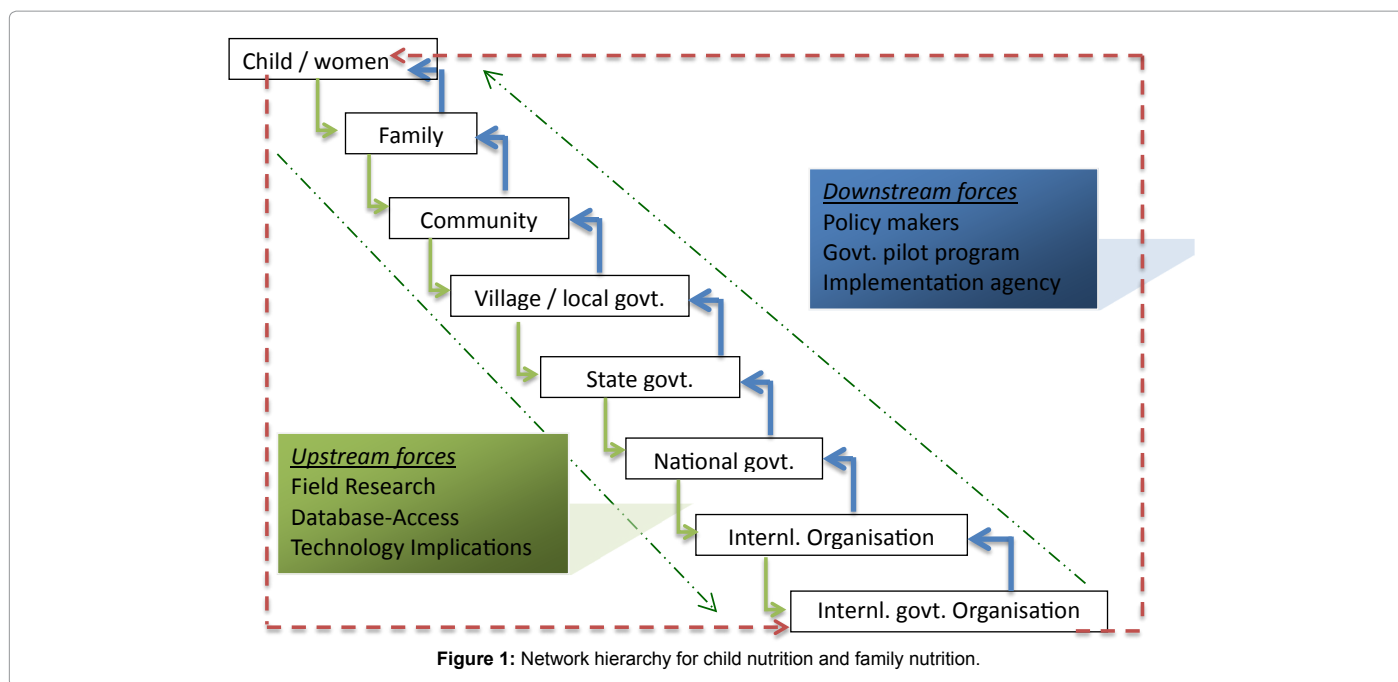
To overcome the complex nutritional disorder among the human beings, the government or NGOs may undertake the supply of the deficit essential nutrients in the form of food based products. To accomplish this challenge, missing nutrient will have to be put into a target food which is consumed by the target population. Many governments have initiated food fortification. Some of the projects have been successful (iodized salt in India); others have been abandoned in mid-way [11]. To be successful, the nature of a program has to be based on very sound planning. Nutritional and health surveys have been executed in large-scale national levels to establish the widespread occurrence of a deficiency disease to precede any such decision. For instance, National Family Health Survey (NFHS) is an ideal database that strengthens India's demographic and health policies and programs, and so far three rounds of survey have been completed since 1992-93 and 4th survey will be conducted in 2014-15. The nutritional-disorder diseases that can be prevented by measures of intervention are caused by vitamin and mineral deficiencies. Foods can also be fortified with amino acids or protein concentrates in order to bring about better utilization of the protein. In the past, many nutritional intervention programs has not been planned for specific target group or objectives as medical sciences proves that personalized medicine is in place now to deal individual disease complex. Thus, nutritional intervention programs also should target specific group to get the immediate impact as medical sciences does. But there are significant factors identified that influences the nutritional intervention as discussed by Austin [12], and those includes (i) demand nutrients, which implies a detailed health and nutrition survey; (ii) commodity system structure, which decides on the vehicle of transfer (e.g. food grains flavour), depending on the food habits, the commodity marketing, and buying habits of the population; (iii) rapid technology for fortification; (iv) consumer acceptability (color and taste), which probably is the core of the success of the project; and, (v) the cost-effectiveness to access. The research on practical methods and feasibility of cereals and other crops fortification has been reviewed by several researchers [13-20] and the increased staple crop production and levels of income of the households has not been caused corresponding reductions in the incidence of chronic hunger and malnutrition. Therefore, fortification of food is need of the hour to tackle the micronutrient disorders especially in urban populations (who have changed their occupations and lifestyles towards refined foods culture) as they have easy access to supermarkets and similar outlets.

Bio fortification of staple crops is need forever

Although the food grains consisted of sorghum, millets and minor food crops constituted negligible percent of food supplies in 1960, but food habit among populations including urban households were had diverse and nutritious food grains as produced from fertile farms. Nowadays the balanced food system is far away as we move towards the starchy foods (Rice, Wheat, Potato etc..) which give enough calories but do not provide enough nutrients, and no adequate attention to such nutritious crop like millets [21]. Besides that, low-fertile and marginal lands bought into food production while most well-endowed cultivable lands become now under infrastructure and residential plots, led us to end with malnutrition and its consequences. Food and nutrition security can be achieved only if adequate food is available and accessible in term of quantity, quality, safety, sociocultural acceptability to live a healthy life. Therefore, wide-ranging and holistic nature of the interventions with a demand driven focus creates an ideal platform for bio fortification initiatives [22,23]. In addition to that a sustained awareness and advocacy of biofortification concepts can be introduced through teaching in schools, adult literacy classes supported by national Govt. and research scientists is the key factor for large-scale social impact. Biofortification is primarily intended to contribute to the prevention of micronutrient deficiencies by reaching all household members those who either not access to or affordable to fruits, vegetables and animal products [23]. Therefore, attempts should be made to improve mineral content in upcoming varieties and hybrids so as to strengthen the growth and vigor of the crop plants, and humans whose health and productivity is completely rely upon the energy and nutrients from their staple foods. Bio fortified cultivars already are in various stages of development for achieving these prospects in the case of vitamin A (maize and cassava), iron (pearl millet and beans) and zinc (rice and wheat) [24]. For instance, Iron bio fortified millet cultivars proven the potential of providing additional bioavailable iron compared to regular millet [25,26]. It is evident that biofortification is sustainable even if external or recurrent financial support fails and it will continuous forever in combating not only sole nutrients that are focused now but also the multiple micronutrient deficiency simultaneously generation after generations in near future.

Future thrust: linking researchers and policymakers

The idea of the right to adequate nutrition to every individual has not been taken seriously, however, there are many nutrition programs implemented internationally and within countries, but they have been provided as a matter of charity, but not completely emphasized. There were no legal data and recourses for those who fail to receive such services. The right to food and nutrition has not been effectively implemented especially in developing and under developed countries. For instance, Indian constitution says that the state shall regard the raising of the level of nutrition and the standard of living of its people and the improvement of public health as among its primary duties and such a civil statement well fit and guide regardless of the countries across the world [27]. The role of policymakers and policies with respect to household nutrition program interventions to the community and individual nutritional status is depicted in Figure 1. The researchers and policy makers need to bring this long lasting burden of malnutrition issues on the intensive research platform involving multi-disciplinary scientists and their approaches for securing food and providing balanced nutrition to the growing world populations. Since nutritional status of women's and adolescent girls has a direct impact on child nutrition and health, therefore, agricultural policy development aimed specifically at improving the diets of women of reproductive age is



crucial to ending the inter-generational vicious cycle of hunger and malnutrition. In this context, biofortification of staple food crops is a natural agricultural alternative to genetically modified crops (or GMO) that are grown in specific countries but not all around the world as it was still under controversial both in terms of complex policy and stringent protocol interventions. Therefore, several optimistic researchers would like to share this old idea to re-think (off course this is not an Einstein idea) and elevate, but with a contemporary approaches with appropriate technology for promoting nutrition oriented agriculture by which re-linking agriculture with nutrition is promising. Further, the ongoing NutriFarm pilot program of Govt. of India, will give best opportunity to push nutri-cereals (all millets) and legumes for surplus production and larger consumption in India for which best candidate cultivars of a staple crop to be identified (if available) or developed (if not available) by the crop breeders. For nutrition point of view, such bio fortified cultivars should be driven to seed chain for distribution to general public. Otherwise, the recently launched nutrition programs by the Govt. of India will never change the face of current situation. The blood of this intervention is entirely relay on availability of nutrient-dense cultivars to meet the nutritional specification. In the most cases, either policy makers or researcher community will fail to interconnect their novel ideas to construct holistic policy changes to succeed in the robust technological world, because of their science politics. Therefore, it is essential to take action towards reforming the health system and policies should be initiated at the highest priority by the national Govt.

Call for collaborative research-for-development

One can raise that why biofortification innovation still not implemented as effectively as other demand-driven innovations (mostly for medical sciences). It is simple to answer that research community focusing biofortification is very small and focusing downstream products (lab to land) compared to other research areas such as climate change, stress resistance, genomics etc. where more upstream research (lab-to-lab) focused. Also working groups are further dived by crops as large number of researchers in major crops (corn, wheat and rice) and small number of researchers on minor crops (millets).

There are lots of opportunities coupled with challenges waiting for international collaboration for this demand-driven approach. To make biofortification as successful strategy for social impact researchers at different disciplinary (agriculturist to nutritionist through gender-sociologist) need to come together. HarvestPlus is an best exaple for such collorative research for development as it is connected more than 200 multi-discipilenary scientific and implementation partners across 40 countries working towards the common goal to reduce hidden hunger by providing micronutrients to billions of people directly through the staple foods. Intrested readers can refer to <http://www.harvestplus.org/> for more details. The effective and sustainable biofortification will be promising only if the public-private sectors collaboration as it could benefit all sectors to develop, produce, and promote micronutrient-dense foods [28]. Thus, national governments could reap impact by the competitive advantage of public sector partners (those will have mandate and responsibility to improve the health of the population), and the private sector partners (as they have experience and expertise in food production, branding and marketing), and the social sector (as a catalyst for grass-roots contact with the consumer).

Conclusion

An ounce of prevention measures is better than the several rounds of curative measures for complex human health disorders. As malnutrition being a widespread across world and obstructed human resources and national development goals, therefore, urgent need for a National Commission on Public Health and Healthcare and related policy changes in developing countries. At the moment, fortification is viable option for developed countries having well-developed infrastructure and delivery system and capable of sustained investment, whereas biofortification is a viable solution to developing countries that are not having aforementioned capacity. The biofortification intends to contribute toward the prevention of micronutrient deficiencies by increasing the daily adequacy of micronutrient intakes among individuals throughout the lifecycle and is simple strategy that will contribute to the overall reduction of micronutrient deficiencies in a population. Therefore, such nutrition

improvement strategies once initiated should be sustained. Over and above biofortification needs to be seen as a supporting tool while other strategies are in place to sustainably increase base levels of household food and nutritional security in a long run and it is not to treat severe micronutrient deficiencies or eliminate them in all population groups. Hence, increased bio fortified crop production by providing subsidized inputs (mineral dense-seed, fertilizer, electricity for irrigation) to some extent to start with will have extreme benefit on food and nutrition security primarily among small and marginal farmers (primary targets) and surplus produce will penetrate into value chain market to benefit secondary and tertiary target populations.

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