Biofortification: A Promising Approach Toward Eradication of Hidden Hunger

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Amita Sharma and Rajnish Kumar Verma

12.1 Introduction

Globally, hunger affects about 11% of the population. The count of undernourished people raised from 777 to 815 million (2015–2016). More than two million people are suffering from malnutrition (FAO, IFAD, UNIICEF, WHO report 2017). Eradication of every type of hunger including chronic hunger (calorie deficiencies) as well as hidden hunger (micronutrient deficiencies) could be accomplished by attainment of a ground-level insight into the consequences and determinants of the problem. In the few preceding decades, the research community has shifted their focus progressing toward development of a sustainable agriculture with elevated quantities of cereal production. Moreover the concern is not merely about production of calorific food but also about production of nutrient-rich food. The latest innovations in food research lead to fortification of food with indispensable minerals, vitamins, fatty acids, fibers, phytonutrients, etc. Biofortification is a practice involving breeding of nutrients into crops, thus providing an approach to deliver nutrients with sustainability, long-term effect, and cost efficiency (Sharma et al. 2017). One should not expect that biofortification is capable of completely eliminating malnutrition, but it is definitely a groundbreaking methodology to meet the daily requirements of nutrient uptake among people (Saltzman et al. 2013; Blancquaert et al. 2017; Cakmak and Kutman 2017).

Both the authors are contributed equally to this chapter.

A. Sharma
Department of Agriculture, Shaheed Udham Singh College of Research and Technology, Tangori, Punjab, India

R. K. Verma (✉)
Department of Botany, Dolphin PG College of Science and Agriculture, Chunni Kalan, Punjab, India

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Biofortification is an advanced approach to complement existing approaches providing nutrients sustainable to people in need at a low cost. It's a feasible methodology to nourish nutrient-deprived people with limited access to supplements, varied foods, and expensive commercially modified food items. Considerable advancement has been witnessed regarding methodology, analysis, and effectiveness of biofortification during recent times (Bouis and Saltzman 2017). But still the process is in the early stages, if scaling and influence of biofortification are taken into consideration. The effect of biofortification on human's health and related disease burden can be estimated with the help of ex ante simulation models (Lividini et al. 2018). In general, these models involve the study of several factors typically estimating the decrease in the incidences of insufficient micronutrient consumption and the number of disability-adjusted life years (DALYs) saved. DALYs represent a method to measure the load of health-linked complications expressed as total healthful life years lost. DALYs actually provide an interpretation of the period and extent of health disorders thereby estimating the burden by counting the total life years (healthy) lost in concerned population because of disabilities and untimely demise (Murray et al. 2012). They can be counted by taking different risk factors into consideration like iron deficiency, protein malnutrition, vitamin A deficiency, childhood underweight, etc. (IHME report 2018). Recently, DALYs metric is employed to perform comparable studies of estimating load of hidden hunger, chronic hunger, and health-related problems (Gödecke et al. 2018). Though economic progress in current times has resulted in a decline of chronic hunger cases, malnutrition is still a challenging situation globally.

12.2 Technologies for Biofortification

To lessen the instances of hidden hunger, interventions include direct as well as indirect methods (Ruel and Alderman 2013). The direct methods (nutrition specific) include supplementation of micronutrients, food modification, dietary diversification, etc. The indirect interventions (nutrient sensitive) aim at fundamental reasons of undernourishment and involve biofortification. Different studies have revealed the point that fortification of foods is a safer technique and have potential impact to confront the challenge of malnutrition among human population. Biofortification could be realized through different technologies like agronomic method, crop breeding, and genetic engineering (Cakmak and Kutman 2017; Blancquaert et al. 2017) (Fig. 12.1).

12.2.1 Agronomic Biofortification

Agronomic biofortification is a practice wherein fertilizer enriched with micronutrients is added to soil and leaves (also known as foliar application). Generally, biofortification of the fundamental foods (sorghum, millet, sweet potato, legumes, wheat, rice, etc.) is the main focus of researchers worldwide, because these crops are

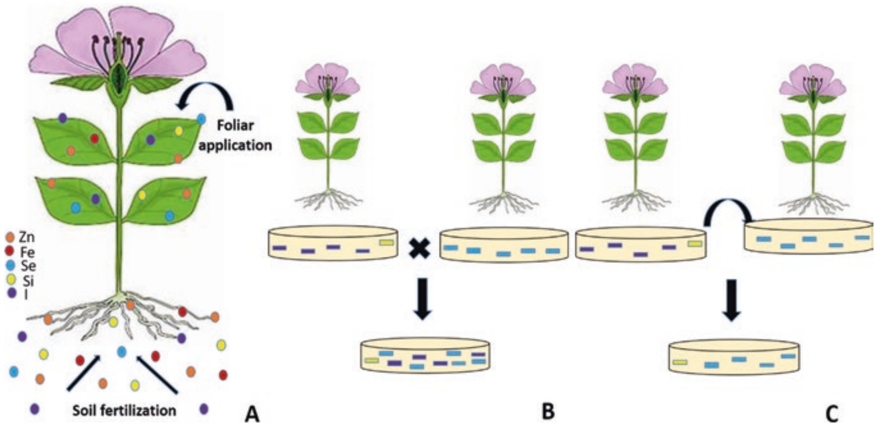

Fig. 12.1 Types of biofortification. (**a**) Agronomic. (**b**) Genetic biofortification (crop breeding). (**c**) Genetic biofortification (gene engineering)

dominant elements of diets especially among the populations at risk or vulnerable populations. Biofortification represents a practical method to target malnourished people with restricted approach to nutrient-rich diverse supplies or food supplements, etc. The best results of agronomic biofortification have been obtained with selenium and zinc (Cakmak 2014). The application of fertilizers enriched with Fe to soil is a challenging methodology as compared to application of Se and Zn, because iron shows precipitation in insoluble forms. The insoluble form is not absorbed by plants, and therefore a successful scheme for Fe enrichment is via foliar treatment or litter fertilization. The victory of agronomic biofortification is determined by many critical aspects which depend upon the availability of nutrients at different stages: accessibility in soil for plant uptake, allocation of nutrients in soil, re-translocation of nutrients into edible plant products, availability of nutrition in foodstuff prepared for man, and physiological stage of individual (Valença et al. 2017).

The intensity of crop enrichment with micronutrients by agronomic biofortification is dependent on the efficacy of fertilizer treatment and type of fertilizer. Fertilizer preparation greatly regulates nutrients' form and their accessibility to crops. Foliar application of micronutrient fertilizers facilitates more uptake of nutrients along with their allocation in crop parts as compared to the fertilizer treatment of soil, especially in case of leafy vegetables and cereals (Lawson et al. 2015). Efficiency of the nutrient uptake is maximum when a combination of foliar and soil micronutrient application is carried out. Coating of seeds with fertilizers is also another successful scheme for micronutrient application. Good soil condition is an additional significant factor to increase the availability of minerals in soil for uptake by the plants (Duffner et al. 2014; Valença et al. 2017).

Application of fertilizers enriched with micronutrients is a considerable approach with least undesirable environmental consequences. Majority of micronutrients don't show susceptibility to leaching as they show strong binding in the soil.

A drawback of this methodology is that these micronutrients got accumulated with time and may be toxic if higher concentrations accumulate repeatedly. Agronomic biofortification is a considerable strategy but represents a temporary way out to enhance micronutrient availability and to match genetic method of biofortification, which is recognized as a better ecological methodology. Agronomic biofortification ensures enhancement in plant yields with improvement in nutritive value when particular micronutrient-crop combinations were utilized (Valença et al. 2017).

12.2.2 Genetic Biofortification

It comprises both the traditional method of breeding and modern methods of engineering at gene level to improvise the nutritional status of the staple food. This strategy represents a single-time venture to raise plants with improved content of indispensable nutrients that can reach the poor and at-risk populations. The benefits of genetic fortification include low costs, one-time investment approach, and distribution of their germplasm at international levels (Melash et al. 2016). The gene-level alteration of crops is considered a justifiable answer to the question of micronutrient insufficiency, but development of novel nutrient-enriched plants is a long process. The success of the methodology is subjected to many factors and their commercialization is greatly affected by degree of public acceptance.

12.3 Advances in Food Biofortification

Biofortification of edible crops with essential nutrients represents an appreciable methodology with immense potential to solve the puzzle of global undernourishment (Fig. 12.2). A myriad of investigations are available in literature utilizing

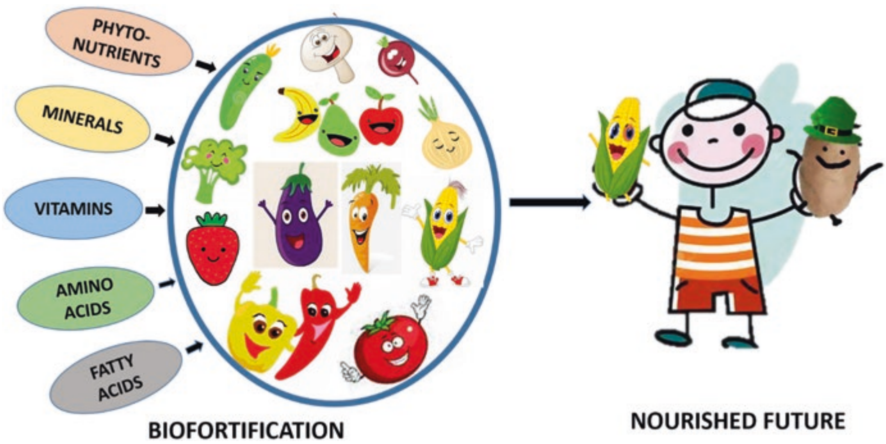

Fig. 12.2 Diagrammatic representation of biofortification approach

different technologies to enrich our cereal crops and other foods with vital nutrients. Till date, numerous cereal crops, vegetables, and fruits are fortified with essential fatty acids, amino acids, minerals, vitamins, phytonutrients, etc., and many investigations are aimed at aspects like bioavailability of nutrients to consumers, public acceptance, etc.

12.3.1 Biofortification with Micronutrients

Modernized agricultural approaches brought about advancement in diversity of crops with high yields. But the present-day scenario demands nutrient-rich crops along with the high-yielding crops. Majority of populations rely on few crops for survival, mainly maize, rice, and wheat. Exploitation of the crops' wild relatives will provide a rich gene supply to modify the crops at genetic level enhancing nutrient status. Moreover, the selective treatment of soil with varied fertilizers also changes the concentration of some micronutrients and their bioavailability to vegetation. Once the plant is ingested, the assimilation of the micronutrients depends on the dietary phytate. The phytate usually shows interactions with nutrients and results in production of insoluble complexes that could be digested or absorbed. So these anti-nutritional compounds should either be absent or be there in least concentrations in the diet. Besides these factors, some cultural practices employed for food process also results in the loss of crucial micronutrients, i.e., vitamins and minerals at different stages. The cultural practices include milling, dehulling, fermentation, cooking, etc. (Melash et al. 2016). Therefore to enrich the staple foods with essential nutrients that can reach our poor and vulnerable populations, biofortification have come up as a substantial approach.

Micronutrients are the compounds that must be supplemented to the human body in minute quantities. It includes both vitamins and minerals. Thus improving the micronutrient content in edible crops is a substantial approach to nourish the poor people with malnourishment. Deficiency of vitamin D leads to various bone diseases and nonskeletal metabolic disorders in various phases of life. Therefore approaches employed for preventing these ailments are of chief importance. Biofortification of edible feedstock with vitamin D have wider impact on the population as compared to supplements (Cashman 2015). Recently, it was found that irradiation of UV leads to biosynthesis of considerable quantities of vitamin D_2. Some cultivated species of mushroom like *Lentinula edodes*, *Pleurotus ostreatus*, and *Agaricus bisporus* have been proven beneficial to meet the demands of vitamin D2 (Taofiq et al. 2017).

Vitamin A deficiency represents a major micronutrient deficiency globally, influencing poor populations excessively in the developing countries. Biofortification by breeding methods and modern engineering methods has proven its capability to improve bioaccessibility of nutrients in crops (De Moura et al. 2015; Beswa et al. 2016a, b; Kamotho et al. 2017; Amah et al. 2018). The Biofortification of maize, sweet potato, and cassava greatly enhanced the retention levels of provitamin A carotenoid (pVAC) in these plants afterwards cooking and storage also (De Moura et al. 2015). Thus, these biofortified crops provided a higher vitamin A content to the consumers. Beswa et al. (2016a, b) reported that nutrient (provitamin A, amino acids, and iron) content of the biofortified maize has been improved with addition of vegetable amaranth in the powdered form. This vegetable powder not only enhanced the provitamin level in fortified maize snacks but also improved the level of phenolic compounds and thus the antioxidant activity. Chaudhary et al. (2016) reported raising biofortified sweet potato varieties with orange or yellow flesh. The color of the flesh is due to the higher content of vitamin A precursor, β-carotene. These sweet potato varieties also provide required dietary fiber and potassium. These varieties have been grown and consumed in Uttar Pradesh, India, reaching the target population to take care of vitamin A deficiency. In a recent study, maize flour biofortification with amaranth enhanced the nutrient value appreciably ($p \leq 0.05$). The levels of protein, calcium, zinc, and iron have been increased in particular. This method of "food to food" biofortification signifies a considerable technology toward fulfilling the requirements of mankind (Kamotho et al. 2017). Globally, banana (*Musa* spp.) is cultivated as an economically principal fruit crop including regions with prevalent VAD conditions. Therefore, biofortification of bananas signifies a noteworthy methodology to alleviate shortage of vitamin A in the vulnerable population (Amah et al. 2018).

Vitamin B_6 includes a group of interrelated complexes which can only be produced de novo by plants and microbes. Insufficiency of vitamin B6 in the diet leads to genetic defects and inflammatory and neurological disorders in vulnerable populations. Thus, vitamin B6 biofortification of food represents a great prospect to lessen load of diseases in poor and vulnerable people, alongside improving stress tolerance (Fudge et al. 2017).

Vitamin B1 (thiamine) deficiency is very common among people dependent on processed rice as the main carbohydrate source. Thiamine is essential to biosynthesize TPP (thiamine pyrophosphate), which acts as an important cofactor of many crucial enzymes. Thiamine buildup in rice crop could be enhanced by overexpression of some genes like *thi4* and *thiC* (Pourcel et al. 2013; Dong et al. 2015). Moreover, genetic engineering of the thiamine production route provides a platform to improvise thiamine content in rice (Minhas et al. 2018). In this study, the editing of the regulatory elements (*cis*-acting) present in gene promoter shifted the biosynthesis of thiamine-binding proteins and transporters to the endosperm region. Thus, the ability to obtain vitamin B1 in rice grains was enhanced by this method of genetic biofortification making the diet wholesome.

Globally, iron deficiency represents a key threat to whole community health. Iron fortification of common bean resulted in enhanced iron buildup in eatable portions with increase in yield, biomass, and expression of antioxidant enzymes (Sida-Arreola et al. 2015). Biofortification of foods with iron enhances its bioavailability to confront the challenge of iron deficiency, in resource-limited populations (Petry et al. 2016). Recently, the efficiency of Fe-biofortified edible crops like beans, rice, pearl millet, etc. was evaluated for improvising iron content in high-risk populations (Finkelstein et al. 2017). In this study random trials suggested that plants biofortified using iron are an effective intervention to develop a good iron status. Outcomes of experiments suggested influence of fortified crops was maximum among people who showed deficiency of iron at the baseline. Recently, iron biofortification of brown rice not only enhanced the iron status but also improved the concentrations of flavonoids and phenolic compounds. The biofortified brown rice showed effective antioxidant properties and enhanced the germination rate of rice (Li et al. 2018).

Zinc is considered as a crucial micronutrient for human health. Witkowska et al. (2015) reported the biofortification of cheese and milk with some micronutrients like Fe(II), Cu(II), Mn(II), and Zn(II), which are considered indispensable for human health. The goats were provided food augmented by soya-based formulations that carried the micronutrients. The fortified milk showed boosted quantities of microelements, i.e., Zn(II) 14.6%, Mn(II) 29.2%, and Cu(II) 8.2%, as compared to control. This designer milk represents the latest version of functional foods to deal with the micronutrient deficiencies prevalent in vulnerable population. In China, wheat was biofortified with zinc by agronomical method, and success of the technology was measured in terms of "disability-adjusted life years" determining health burden. In major wheat-growing regions, appreciable results were achieved with the biofortified wheat where diseases due to deficiency of Zn showed reduction up to 56.6% (Wang et al. 2016). In a similar study, Zn biofortification programs were designed with a leafy vegetable, like *Brassica oleracea* cv. Bronco (Barrameda-Medina et al. 2017). Zinc supplementation (80–100 μM) was observed to be optimal for sustaining normal plant development with promotion of Zn concentration in *B. oleracea* edible parts. Further enhancing the Zn concentration leads to induction of amino acid buildup with increase in biosynthesis of phenolics and glucosinolates in leaves. The agronomical fortification of edible plants, viz., wheat and rice, with Zn is a viable strategy for a healthy and nourished future. It not only provides food and health security but also reduces the load of diseases from the human population (Kadam et al. 2018).

Iodine represents a crucial micronutrient indispensable for human health. Biofortification of lettuce by iodine fertilization of soil was observed to be a successful approach to improvise the iodine levels in individuals of target populations (Kopec et al. 2015). In this study besides biofortification of crop with iodine, its effect on Wistar rats was also studied to gain insights into different aspects of accumulation of iodine in animal tissues and health-related benefits. The rat serum was examined for different biochemical parameters and majority of tissues showed iodine concentrations higher than the control rats. This highlights victory of the biofortified crops in dealing with micronutrient deficiency. In a similar study, soil and foliar fertilization of vegetables resulted in an increase in iodine accumulation in various parts of plants (Lawson et al. 2015). The foliar application of iodine provided superior outcomes than the soil fertilization in this experiment.

Selenium has been established as a crucial constituent of a balanced human diet owing to its antioxidative and anti-oncogenic properties. Selenium-enriched *Brassica* crops were developed by agronomic biofortification and biofortified cabbage seedlings showed boosted quantities of antitumor activity (Oancea et al. 2015). Comparable findings were observed with another *Brassica* crop, i.e., broccoli (*Brassica oleracea* Italica), which was biofortified with Se. In this investigation, the mature stages of biofortified broccoli possessed considerably higher contents of phenolic complexes and showed better antiproliferative and antioxidant activities (Bachiega et al. 2016). Mushrooms represent another fundamental crop that can be targeted for selenium biofortification. An edible medicinal mushroom *Cordyceps militaris* was utilized for biofortification, resulting in enhanced selenium content in fruiting bodies. These reproductive bodies exhibited enhanced biological efficiency and antioxidative properties (Hu et al. 2018). In a different study, selenium content in biofortification of edible mushrooms (*Pleurotus* sp.) was performed to analyze its efficacy (Kaur et al. 2018). Wheat straw with high selenium levels was used for successful farming of *Pleurotus* sp., i.e., *P. florida*, *P. sajorcaju*, and *P. ostreatus*. The mushroom extracts showed considerable upgrading in the antioxidant profiles and total protein content. The utilization of wheat straw (Se-rich) not only enhanced the selenium contents in the cultivated mushrooms but also presented a way to make use of this underutilized substrate. Moreover, utilization of wheat straw will reduce air pollution as this waste is mostly burnt by the farmers if not utilized. Mushrooms represent a healthy food for mankind and selenium fortification will enhance their nutritional potential to target vulnerable and at-risk populations.

Biofortification of foods with silicon represents an innovative implement to develop nutritionally valuable diets with good consequences on bone strength. D'Imperio et al. (2017) studied the success of fortification of leafy vegetables (Swiss chard, mizuna, tatsoi, chicory, and purslane) with silicon as a health-promoting strategy. In vitro analysis was performed to analyze the probable health-supporting results of biofortified vegetables on mineralization of bones as compared to market-available silicon supplement.

12.3.2 Fortification with Amino Acids

Man and animals don't possess the ability to biosynthesize many amino acids de novo which are crucial for their health. Therefore indispensable amino acids should be taken by man and animals in their diets. Nine crucial amino acids are phenylalanine, methionine, valine, lysine, tryptophan, histidine, threonine, isoleucine, and leucine. As these compounds have high nutritional value, amino acid biofortification of edible foods is considered a foreseeable methodology owing to their very less concentrations in major staple crops (Galili and Amir 2012; Galili et al. 2016; Yang et al. 2016).

Among the principal crops like cereals and legumes worldwide, the amino acids methionine and lysine are present in less concentrations. So biofortification with these amino acids represents a successful strategy to make the crops nutritionally favorable (Galili and Amir 2012). In a similar study, a major staple crop, rice, was modified to boost up concentration of an amino acid, lysine. The rice crop was genetically engineered to overexpress enzymes dihydrodipicolinate synthase and aspartate kinase to get enhanced accumulation of lysine. Higher levels of lysine were obtained by impeding enzymatic action of lysine ketoglutarate reductase in rice (Yang et al. 2016). Recently, combination of varied scientific strategies like biochemical approaches, reverse genetics, and transgenic methods was exercised to study genes expressing enzymes crucial for biosynthesis, degradation, and regulation of crucial amino acids (Galili et al. 2016). Despite the employment of varied approaches, very little success has been achieved in biofortification of edible foods with amino acids as limited genetic resources for breeding methods are available and also high levels of indispensable amino acids generally restrict the plant growth. To design better transgenic plants, an improved insight into amino acid biosynthetic and regulatory pathways is need of the hour, to boost up indispensable amino acid content of cereal crops and horticultural plants (Wang et al. 2017).

12.3.3 Fortification with Essential Fatty Acids

Omega-3 acid (α-linolenic acid [ALA]) and omega-6 acid (linoleic acid [LA]) are indispensable fatty acids as animals or human beings are incapable to biosynthesize them. These fatty acids produce crucial fatty acids like docosahexaenoic acid (DHA), arachidonic acid (ARA), and eicosapentaenoic acid (EPA) owing to their important contribution in management of homeostasis (Saini and Keum 2018). The scarcity of crucial fatty acids is the principal reason of prevalence of autoimmune/inflammatory and cardiovascular diseases. The evidences throw light on the crucial importance of polyunsaturated fatty acids (PUFAs). The long-chain PUFAs (omega-3) are significantly important for controlling brain growth and functioning along with the maintenance of cardiovascular health (Hefferon 2015; Saini et al. 2018). Although fish is a rich source of PUFAs, consumption of fish is limited due to many factors. Thus alternative strategies must be employed to find other PUFA-rich sources for a sustainable supply to target population.

Among efficient approaches, one is genetic biofortification of plants to synthesize PUFAs. Genetic biofortification of oilseed crops and *Arabidopsis thaliana* was performed for expressing omega-3 PUFA at concentrations equivalent to those present in marine systems (Ruiz-Lopez et al. 2012; 2014). Seed oil plants were biofortified with other crucial fatty acids like arachidonic acid, γ-linolenic acid, and stearidonic acid (Haslam et al. 2013). The engineering of the metabolic pathway involved in biosynthesis of omega-3 fatty acid was reconstructed in plants like false flax, and its increased quantities have been obtained (Adarme-Vega et al. 2014). In a recent study, genetically biofortified safflower was developed that produced enhanced concentrations of alpha-linolenic acid (ALA). The seeds of the crop accumulated ~78% of the linoleic acid which act as direct precursor of ALA (Rani et al. 2018).

12.3.4 Fortification with Phytonutrients

Phytonutrients are the bioactive compounds extracted from plants which confer health benefits to humans. The intake of vegetables and fruits with high phytochemical content results in health-promoting effects like lowering predominance of severe disorders, besides prolonging the shelf life and commercial value (Zhu et al. 2013; Ilahy et al. 2018). Antioxidants are the bioactive compounds that interact with reactive oxygen species (ROS) thereby checking oxidative damage to the components of the cell. This reduces the death rate of cells ultimately decreasing rapidity of ageing and related diseases. Foods biofortified with vitamins (e.g., vitamin C and E) also possess enhanced antioxidant properties thus enabling the consumers to combat different types of stress conditions (Amaya et al. 2015). High expression of vitamin C was obtained in transgenic stylo and tobacco plants and also improved the tolerance power of these plants against chilling and drought stress (Bao et al. 2016). The latest innovations in technologies resulted in an improvised insight into the biosynthesis of vitamin C and accelerated renewed interest in development of new functional foods by overcoming limitations associated with vitamin C biofortification (George et al. 2017).

An important class of antioxidants that could be utilized to biofortify the crops include flavonoids. The success rate of the crop biofortification program with flavonoids is dependent on the point that the increased production of antioxidants must not affect the plant's overall growth and fitness (Zhu et al. 2013). In a similar study, cherry tomato was biofortified with potassium, and higher accumulation of this micronutrient leads to improvement in storage of these fruits post harvesting. The fruits of cherry tomato showed better storage through antioxidant response with reduced peroxidation of lipids and efficient regeneration of ascorbic acid (Constán-Aguilar et al. 2014). Anthocyanins represent another class of phenolics that possess high antioxidant properties. The genetic biofortification of anthocyanins in staple crops, like rice, can promote improvisation of human health. A novel rice germplasm was generated by this genetic alteration of rice known as "Purple Endosperm Rice," which showed high contents of anthocyanin and subsequently high antioxidant activity (Zhu et al. 2017). A maize variety biofortified with provitamin A carotenoids was observed to be a good functional food to target vulnerable and at-risk populations in the developing countries. This variety revealed a rich mine of tocochromanols, vitamin E, phenolic compounds, etc. and thus showed heightened antioxidative nature (Muzhingi et al. 2017).

In the current scenario, foods are biofortified to improve their postharvest quality. The enhancement in pigment buildup in tomatoes boosted up availability of the phytonutrients in biofortified crops besides prolonging shelf life. All these factors provided a boost in the marketability of biofortified crops (Ilahy et al. 2018). In a similar study, tomatoes showed enhanced accumulation of minerals and natural antioxidants when they were grown on earthworm-grazed and *Trichoderma harzianum*-biofortified SMS (spent mushroom substrate). This substrate inhibited the peroxidation of lipids and protein oxidation along with considerable enhancement in content of polyphenols and flavonoids in tomato. Thus, it's a substantial example of an environment-friendly and practical methodology that comes up with biofortified tomatoes possessing high radical scavenging properties (Singh et al. 2018).

12.4 Public Acceptance and Concerns

The accomplishment of the biofortification approach to address the challenge of undernourishment universally depends upon many factors like cost efficiency, nutrition impact, acceptance by target consumers, sustainable implementation of products, etc. Numerous experimental findings have unfolded a comprehensive picture of approval of biofortified crops by consumers (Birol et al. 2015; Steur et al. 2017; Ricroch et al. 2018). These studies were founded on the interdisciplinary research methods involving sensory evaluation and consumer testing methods. Sensory evaluation represents a scientific method involving measurement and interpretation of man comebacks for various food products, identified through the sensory perceptions, viz., sight, odor, touch, odor, sound, and taste. Consumer or hedonic testing involves the measurement of personal response of consumer like preference, liking, or acceptance for concerned produce. A greater acceptance of the biofortified crops by the target consumers ensures better delivery and marketing of these crops (Birol et al. 2015). The approval of genetically altered biofortified crops totally depends on perception of this approach by the common people. The awareness of the public about the potential of the green biotechnology to combat the matter of undernourishment and calorie deficiency must be enhanced to ensure full acceptance of biofortified crops by the target consumer. As common people don't have thorough access to scientific technologies and practices used in agriculture, it is difficult to guarantee victory of biofortified crops in the market, and that considerably affects the perception of transgenics by the public. A number of ethical facts were proposed in different studies concerning utilization of transgenic biofortified crops, but, morally, biofortification advantages must reach one and all, especially the poor and vulnerable groups of populations (Ricroch et al. 2018).

To produce nutritionally valuable crops, much work must be done with involvement of different scientific disciplines like molecular biologists, plant biotechnologists, plant breeders, nutritionists, and even socialists. Biofortification of plants will gain success and will be considered worthwhile only if the people are prepared, knowledgeable, and ready to acknowledge this technology or modifications in the crop appearance. The newer nutritionally improved crop varieties must be evaluated at clinical alongside market level and must be provided to the populations who can benefit most from them. These target populations should be perceptive to the point that these crops with high-level nutrient enrichment will influence the overall health of the community. Cooperative action of governments, nonprofit organizations, and industries will promote true elimination of the hidden hunger especially from the poor and at-risk populations (Hefferon 2015; Ricroch et al. 2018).

12.5 Conclusion

A massive percentage of the Earth's population is encountering malnutrition; the foremost victims are people of developing countries. Although recent advances have contributed a lot to change the scenario, the question of undernutrition remains unanswered. The estimation of fundamental factors throws light on the still unsettled problem of malnutrition. Hidden hunger still poses as an obstacle in developing a healthy world. Studies underlined the grim situation that this crisis of malnutrition will turn out to be more prominent in the coming times. Unfortunately, our principal staple crops lack majority of the fundamental nutrients such as amino acids, vitamins, fatty acids, and minerals that are critical for usual growth and survival. Quite a few tactics were proposed to boost up the quality besides quantity of the staple food; among them, biofortification is an innovative and emerging practice to curb the risk of hidden hunger by increasing the bioaccessibility of key nutrients. To formulate the biofortification program as a successful strategy, effective implementation of biofortified products plays a major role, and it requires constant examination, quality guarantee, regulatory control, and remedial actions to ensure compliance of all factors.

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