Chapter

Breeding Vegetables for Nutritional Security

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Abstract

The most dominant vegetables in the global food economy are tomato, cucurbits, (pumpkin, squash, cucumber and gherkin), allium (onion, shallot, garlic) and chili. These vegetables are consumed in nearly all countries although with much variation in shape, size, color and taste, while the marketing of global vegetables accounts for significant revenue streams, traditional vegetables often have superior nutritional properties. Biodiversity is considered essential for food security and nutrition and can contribute to the achievement through improved dietary choices and positive health impacts Through conventional breeding approach, it is possible to develop new vegetable varieties or integrate the favorable genes for neutraceuticals, bioactive compounds and edible color into cultivated varieties. Advances in molecular biology and recombinant technology have paved the way for enhancing the pace of special trait variety development using marker assisted breeding and designing new vegetable crop plants following transgenic approach.

Keywords: biodiversity, neutraceuticals, conventional breeding, MAS, transgeneics

1. Introduction

Vegetables are increasingly recognized as an essential source for food and nutrition security. Vegetable production provides a promising economic opportunity for reducing rural poverty and unemployment in developing countries and is a key component of farm diversification strategies. Vegetables are mankind's most affordable source of vitamins and minerals needed for good health. Today, neither the economic nor nutritional power of vegetables has not been sufficiently realized. To tap the economic power of vegetables, Governments will need to increase their investment in farm productivity (including improved varieties, alternatives to chemical pesticides, and the use of protected cultivation), good postharvest management, food safety, and market access. To tap the nutritional power of vegetables consumers need to know how vegetable consumption must therefore be nurtured through a combination of supply side interventions and communication emphasizing the importance of eating vegetables, governments and donors will need to give vegetables for good nutrition and health, to fully tap the economic and nutritional power of vegetables, much greater priority than they currently receive. Now is the time to prioritize investments in vegetables, providing increased economic opportunities for smallholder farmers and providing healthy diets for all.

Fruits and vegetables are essential sources for the micronutrients needed for healthier diets. Potassium in vegetables helps to maintain healthy blood pressure, their dietary fiber content reduces blood cholesterol levels and may lower the risk of heart disease, folate reduces the risks of birth defects, and vitamin A keeps eyes and skin healthy, while vitamin C not only keeps teeth and gums healthy but also aids in iron absorption. Recognizing the important nutritional benefits of fruits and vegetables, the World Health Organization (WHO) recommends a minimum intake of 400 g per day to prevent chronic diseases (especially heart diseases, cancers and diabetes) and supply needed micronutrients (especially calcium, iron, iodine, vitamin A and Zinc). However, consumers today even those with higher incomes, are believed to be missing this target. More attention in filling this dietary gap and enabling consumers to take the nutritional power of vegetables is required.

2. Vegetables in global food economy

The most dominant vegetables in the global food economy are tomato, cucurbits, (pumpkin, squash, cucumber and gherkin), allium (onion, shallot, garlic) and chili. These vegetables are consumed in nearly all countries although with much variation in shape, size, color and taste, while the marketing of global vegetables accounts for significant revenue stream, traditional vegetables often have superior nutritional properties. For instance, 100 g of leaves of amaranth or vegetable cowpea can provide over 100% of the vitamin A needs of pregnant women. Globally, a one per cent increase in per capita income in developing countries is associated with a 0.5% increase in per capita vegetables availability. It follows that the bulk of the global supply of fruit and vegetables (77% of total value) is produced in populous middleincome countries. China accounts for 45% of the global value of vegetable production. India comes second, accounting for eight per cent of global vegetable production. Vegetables play a major role in world agriculture by providing food and offering nutritional and economic security.

3. Health promoting nutrient compounds in vegetables

Macro carotene, nutraceuticals, phyto-chemicals are bioactive compounds which are either plant pigments (lycopene, ß carotene, anthoyanin, lutein, capsanthin, zeaxanthin *etc.*) or secondary metabolites (Flavonoids, isothiocyanates, glucosinolates *etc.*) found in most of the vegetables which provide color, flavor and texture and protect the plants

Antioxidants: Phyto-chemicals with antioxidant activity are carotenoids (a-carotene, lycopene, zeaxanthin, cryptoxanthin, lutein) flavonoids and polphenols present in vegetables.

Flavanoids: Vegetables such as kale, spinach, Brussel's sprouts, sprouting broccoli, beets, red bell-pepper, onion, corn, eggplant, cauliflower and cucumber are also rich source of flavonoids hence, have potent antioxidant activity.

Plant pigments: Plant pigments are edible colors found in tissue of plants which includes anthocyanins, betalains, carotenoids and chlorophylls.

Edible colors: Edible colors are natural pigments found in tissue of plants. These colors are the chemical compounds produced by several biochemical pathway and gives colors to the food. These colors are changed according the growth stage of the plant parts or vegetable product. These include anthocyanins, betalains, carotenoids, chlorophylls. These pigments play important ecological and metabolic functions in the plants [1] and are more frequently exploited as the source of nutraceuticals to address a number of human ailments.

Betalains: Betalains have been widely used as natural colorants for many centuries but their attractiveness for use as colorants of foods (or drugs and cosmetics) has increased recently due to their reportedly high anti-oxidative free radical scavenging activities, and concerns about the use of various synthetic alternatives.

Chlorophylls: Chlorophyll is the most important plant pigment which has the potential to act as a chemo-preventive compound in humans. Chlorophylls, in contrast, are typically consumed in much higher doses in a diet that incorporates green and leafy vegetables [2]. The anti- mutagenic properties of chlorophylls have neen demonstrated in various assays, and clearly, intake of chlorophyll has potential to act as a chemopreventive compound in humans.

Anthocyanins: Anthocyanins are natural pigments belonging to the flavonoid family. They are responsible for the blue, purple, red and orange color of many fruits and vegetables. Anthocyanins are capable of acting on different cells involved in the development of atherosclerosis, one of the leading causesa to cardiovascular dysfunction. Anthocyanins and the aglycone cyaniding were found to inhibit cycloxygenase enzymes, which can be one market for the initiation stage of carcinogenesis. On one hand they can interfere with glucose absorption and on the other hand they may have a protective effect on pancreatic cells. The most extensively documented phytomedicinal role of anthocyanin pigments is in improving eyesight including night vision.

Carotenoids: Carotenoids are the second most abundant pigments in nature, and consist of more than 700 members [3]. Carotenoids play an important role in plant reproduction, through their role in attracting pollinators and in seed dispersal, and are essential components of human's diets. Carotenoids provide protection to vision and eye function, and against macular degeneration and cataracts. Carotenoids are credited with biological promotion of immune system response. Carotenoids are associated with inhinition of several types of cancers including cervical, esophageal, pancreatic, lung, prostate, colorectal and stomach.

4. Antinutrient factors

Plants produce many defense strategies to protect themselves from predators and many of these, such as resveratrol and glucosinate, which are primarily pathogen-protective chemicals also have demonstrated beneficial effects for human health. Many, however, have the opposite effect. For example, phytate, a plant phosphate storage compound, is an antinutrient as it strongly chelates iron, calcium, zinc and other divalent mineral ions making them unavailable for uptake. Different antinutrient compounds (phytates, oxalates, trypisn inhibitors, lectins etc.), food allergens (albumins, globluins etc.) and toxins (glycoalkaloids, cynogenic glucosides, phyto-hemaglutinins) in crop plants need to be reduced to enhance nutrient potential of the vegetables.

5. Breeding nutrient rich varieties

Vegetables are valued for their extrinsic and intrinsic quality traits. Diet rich in vegetables provide micronutrients and health promoting phytochemicals that alleviate malnutrition. The beneficial health effects are mainly attributed to diverse antioxidant compounds such as vitamins, carotenoids, phenolics. Alkaloids, nitrogen containing compounds, organouslphur compounds etc. Although, chief long term breeding objective will continue to be increasing yield to meet the food requirement of ever increasing population, in order to ensure health security to our countrymen and multipurpose utility of the varieties for fresh market and industry suitability, it is imperative that nutraceutical, edible color and bioactive compound rich vegetable varieties are bred ensuring high remuneration to farmers. Quality in vegetables is a complex character influenced by both genetical and environmental factors. Breeding for quality has been unsystematic and often empirical but significant progress has been made in several vegetable crops. Conventional breeding in conjunction with molecular biology has bright prospects of developing vegetable varieties high in neutraceuticals, edible colors and bioacticve compounds suitable for fresh market as well as developing functional fusions food industry.

Conventional breeding uses inherent properties of the crop, having far reaching impact on communities and has fewer regulatory constraints compared to genetically modified varieties. Breeding efforts targeting improved micronutrient content and composition began in the 1940s and 1950's, with research describing the inheritance and development of tomato breeding stocks high in pro-vitamin A carotenoids and vitamin C. Similar research leading to the development of darker orange and consequently high pro-vitamin A, carrots began in the 1960s. Since then genetic improvement to increase levels of specific micronutrient has been pursued primarily in several vegetables.

A significant genetic component of iron and zinc content of edible plant parts has been noted, but parallel investigations for calcium are not widely reported for many plant species and even less is known about magnesium. As progress is made in breeding for crop yield, mineral content usually is reduced. Furthermore, breeding for improved mineral use efficiency usually does not alter mineral content of edible plant parts. Success in breeding for higher mineral content must consider not only mineral concentration but also organic components in plants that can be abundant and either reduce (phytate, phenolic compounds) or increase (vitamin C) bioavailability. Recent studies have exhibited a broad range of calcium, iron, and zinc content across a range of Andean potato cultivars [4].

5.1 Genetic resources

Biodiversity is considered essential for food security and nutrition and can contribute to the achievement through improved dietary choices and positive health impacts. However, it is seldom included in nutrition programmes and interventions. Dietary diversity depends not only on a diversity of crops but also on diversity within crops. There is an increasing body of evidence of wide variation in nutrient contents within species, but data are lacking on nutrient composition and dietary intake for many underutilized species as well as for cultivars within species. Such information is needed both to enhance use of more nutritious cultivars in diets and to make them available for use in breeding programme aimed at increasing the nutrient content of more commonly used varieties for the same species, eliminating the need for transgenic modifications.

Genetic resources are the foundation block that are essentially required for evolving improved crop varieties when the breeder aim at adding more desirable traits to an otherwise acceptable varieties. This necessitates availability of the desired variability to the breeder within the land races, putative ancestral form, primitive cultivars and obsolete cultivars, heirloom cultivars of these crops or its wild forms and other elated species constituting primary, secondary and tertiary gene pools. The utilization of plant genetic resources to enhance the chemical composition of horticultural crops through biotechnology or conventional breeding has led to the development of varieties with enhanced levels of micronutrients, such as enhanced beta-carotene sweet potatoes, potato, carrot. Pavithra *et al*. [5] found tomato lines rich in Zn content. The elite germplasm line with high Zn content may be used to prospect candidate gene for improving nutritional value.

5.2 Breeding for nutraceutical bioactive compounds

Nutraceutical bioactive and edible colors are natural compounds which are regulated by several biochemical pathways and controlled by genetical and environmental factors. From early times people knowingly or unknowingly selected several vegetable crops for their food purpose. There are many or cultivated vegetables which are rich in these beneficial compounds. The biochemical pathway and synthesis of these compounds are controlled by one or many genes which are scattered in the available or unknown germplasm of particular vegetable crop. India is endowed with diverse agroclimatic regions ranging from tropical to temperate making it possible to grow all kinds of vegetable crops in one or the other corners of the country. Besides, there is plenty of diversity in different vegetable crops which can be exploited for development of special varieties. Through convention breeding, it is possible to develop new vegetable varieties or integrate the favorable genes for nutraceuticals, bioactive compounds and edible color into cultivated varieties, advances in molecular biology and recombinant technology have paved the way for enhancing the pace of special trait variety development using marker assisted breeding and designing new vegetable crop plants following transgenic approach.

5.3 Breeding techniques

Breeding method in any crops depends upon the breeding system and genetic architecture resulting from natural selection as well as human selection during the course of cultivation. The genetic architecture or the pattern of inheritance of characters is another important consideration while determining the most appropriate breeding procedure applicable to any particular crops. The choice of breeding method would be largely guided by nature of gene action and relative magnitude of additive genetic variance, dominance variance and epistasis in a breeding population. The efficient breeding procedure should be effective in manipulation and selection of favorable gene combination, additive genetic variance, exploitation of dominance variance and achieving close relationship between expected genetic gain and realized progress from selection. Development of F_1 hybrid is very suitable for enhancing nutraceuticals and edible colors. The beta-carotene content in muskmelon has increased manifold in F_1 hybrid [6].

5.4 Advanced breeding techniques

5.4.1 Mutation breeding

In a simple way, mutation is a random or directed change in the structure of DNA or the chromosome which often result in a visible or detectable chance in specific character or trait. In self-pollinated crops, it is well known whereas in cross pollinated crops its application is more difficult and identification of the origin of the desirable genotypes is difficult. Sapir et al. [7] reported in tomato that *high pigment 1* (*hp-1*) mutation known to increase flavanoids content in fruits.

5.4.2 Polyploidy breeding

Polyploid can be induced due to aberration in cell division. This may occur both in the mitosis as well as in meiosis. This method can be used successfully in vegetable breeding as a means of enhancing nutraceuticals and colors in vegetables.

Tetraploids in radish, pumpkin, and watermelon are highly productive and have improved quality. Zhang *et al*. [8] developed tetraploid muskmelon which is rich in vitamin C which is higher than those in the diploid fruit.

5.4.3 Haploidy breeding

The development of haploids in a number of plant species is now recognized as the most rapid route to the achievement of homozygosity and production of pure lines. Currently, little breeding effort is going on for improvement of *brassica* for nutraceutical species and as indicated, there are very few successful double haploid protocols.

5.5 Biotechnological approaches

5.5.1 Molecular markers and marker assisted selection (MAS)

Molecular markers such as RAPD, ISSR, SSR, SCAR, CAPS are used to study linkage with gene(s) responsible for high neutraceuticals, bioactive compounds and edible colors using mapping population. Of late, use of SNP marker is becoming more common. In Marker Assited Selection, a marker (morphological, biochemical or DNA) is used for indirect selection of a trait of interest. The mapping populations such as Near Isogenic Lines (NILs), Recombinant Inbred Lines (RILs) are used to identify the molecular markers linked to genes of interest. Ripley and Roslinsky [9] identified an ISSR Marker for 2 propenyl glucosinolate content in *Brassica*.

5.5.2 Quantitative trait loci (QTL) analysis

QTL analysis is the study of the alleles that occur in a locus and the phenotypes. Most traits of interest are governed by more than one gene, defining and studying the entire locus of genes related to a trait gives hope of understanding the effect genotype of an individual. The advent of molecular maps and the derived quantitative trait locus (QTL) mapping technology has provided strong evidence that despite the inferior phenotype, exotic germplasm is likely to contain QTLs that can increase the quality of elite breeding lines. Bin 3-C has previously been described as harboring a single gene mutation *r* yellow flesh in tomato [10].

5.5.3 Advanced backcross QTL analysis

The AB-QTL strategy has so for been tested in tomato and pepper. The most extensive experiments have been conducted in tomato, where populations involving crosses with five wild *Lycopersicon* species have been genotyped and field tested in a number of locations around the world for numerous traits important for the tomato processing industry. Through the application of marker and phenotypic analysis of segregating generations of the cultivated tomato and wild *Lycopersicon* species, QTLs for improved fruit color had been revealed. QTLs that improve fruit color originating from red-fruited (*S.pimpinellifolium*) and green fruited (S.*habrochaites, S parviflorum*) wild relatives had been detected in segregating populations of crosses of these species and the cultivated tomato. Quantitative trait loci associated with carotenoids and tomato fruit color using introgression populations of *S.pennellii*, *S peruvianum* and *S. habrochaites* have been described by [11].

5.5.4 Introgression line (IL) libraries

IL libraries contain homogenous genetic backgrounds, only differing from one another by the introgressed donor segment. A tomato introgression line population that combines single chromosomal segments introgressed from the wild, green fruited species *Solanum pennellii* in the background of the domesticated tomato, *Solanum lycopersicum* was used to identify QTL for nutritional and antioxidant contents. Liu *et al.* [12] applied the candidate gene approach to link sequences that have known functional roles in carotenoid biosynthesis to QTLs that are responsible for the variation of the tomato red fruit color.

Marker assisted backcross breeding has been used successfully to incorporate genes or QTL for both qualitative and quantitative traits in a number of crop species especially tomato, cucumber, potato, in some cases leading to the development of improved cultivars. Of late Indian cauliflowers are being introgressed with semi-dominant mutant *Or* gene to enhance their betacarotene content in an attempt to tackle malnutrition problem by making diverse beta- carotene rich food available to consumers.

Interspecific crosses with wild species transferred the ability to produce small quantities of anthocyanins into the peel of cultivated tomatoes. For example, the dominant gene Anthocyanin fruit (*Aft)*, which induces limited pigmentation upon stimulation by high light intensity, was introgressed into domesticated tomato plants by an interspecific cross with *S. chilense* and the gene Aubergine (*Abg*) from *Solanum lycopersicoides,* Furthermore, the recessive gene atroviolacea (*atv*), derived from the interspecific cross with *Solanum cheesmaniae* that stimulate strong anthocyanin pigmentation in the entire plant, particularly in vegetative tissues. Fruits with either *Aft* and *atv* alleles or *abg* and *atv* alleles have been obtained with higher production of anthocyanins in the peel, ranging in total amount from 1 to 4 mg/g fresh weight of peel. Anthocyanins were found in the skin and flesh of certain cultivars of potato. Total anthocyanin concentrations in Andean potatoes ranged from 14 to 16, 330 μg/g DW [4]. Usually, cultivars high in anthocyanins are low in carotenoids and *vice versa*. The fruit color of red chili is genetically determined by three loci *y*, *cl*, and c*2* Recently the gene for capsanthin-capsorubin synthase (CCs) has been considered as candidate gene for the *y* locus. The relationship between the phytoene synthase and carotenoid content in chili was tested with interval mapping using QTL analysis revealed that they were detected only at the *PSY* locus.

Singh *et al*. [13] observed enormous diversity in pigmentation of European and Asiatic carrot.The Asiatic types are mostly yellow and purple. The Asiatic type collection Local Rewari Black and Local Jaipur Black have higher anthocyanin content. Few molecular markers linked to major genes or QTL have been developed for carotene [14] and the Y_2 gene and the *Rs* sugar type gene. To date, seven monogenic traits have been mapped for carrot: *yel, cola, Rs, Mj-1,* Y, Y_2 and P_1.QTL have been mapped for carrot total carotenoids and five component carotenoids: phytoene, x-carotene, ß-carotene, zeta-carotene, and lycopene [14] and the majority of the structural genes of the carotenoid pathway are now placed into this map. Anthocyanin accumulation in the carrot phloem is conditioned by the P_1 locus, with purple (P_1) dominant to non purple (p_1). From the inheritance studies of Eastern carrot germplasm, it is concluded that the P_1 and Y_2 loci are unlinked.

The common cucumbers always develop white fruit with lower carotenoid, 22 48 μg/100 g fresh weight. While Xishuangbanna gourd (*C sativus var.xishuangbannanesis*) develops orange fruit rich in carotenoid, approximately 700 μg/100 g flesh weight, which makes this germplasm attractive to plant improvement programme. QTL associated with orange color fruit flesh showed two genetic linkage maps with the markers of RAPD, SCAR, SSR, EST, SNP, AFLP and SSAP, which defined a common collinear region containing four molecular markers on linkage group LG6 inMAP1 and LG 3 in Map 2.

SCAR markers linked to the *Or* gene were identified based on random amplified polymorphic DNA (RAPID) and amplified fragment length polymorphism (ALPH) by performing a bulked segregant analysis (BSA) using a double haploid (DH) population derived from the F_1 cross between 91 and 112 (white head leaves) and T12–19 (orange head leaves) *via* microspore culture. On the basis of linkage analysis, the *Or* gene was mapped in a region conversing a total interval of 4.6 cM between two SSR markers derived from BAC clones AC172873 and AC189246 at the end of linkage group 9, which matches with chromosome I of A genome in Chinese cabbage. A genetic map of the 'or' locus was constructed by using five SSR markers and two morphological markers. Three SSR markers were tightly linked to o*r* and two of them, *sau* (C) 586 and *syau* 19, were located on the same side at distances of 1,6 and 1,3 cM, respectively. The other marker, *syau* 15, was located on the other side at a distance of 3.3 cM. Cervantes-Flores et al. [15] have recently reported QTL for dry matter, starch content and ß-carotene content, opening up the possibility of genetic manipulation and further enhancement of sweet potato. Ripley, V.L. and Roslinsky, V [9] identified ISSR marker for 2- propenly glucosinolate content in Brassica. Efforts are also being made to use the genetic and molecular approaches for increasing the leaves of tocopherols in potato tubers through metabolic engineering tools and techniques.

6. Transgenic approach

Three genes, encoding phytoene synthase (*CrtB*), phytonene desaturase (*Crt1*) and lycopene beta – cylase (*CrtY)* from *Erwinia* have been introduced in potato to produce beta carotene. Romer *et al*. [16] developed transgenic tomato to enhance the carotenoid content with the bacterial carotenoid gene (*crtl*) encoding the enzyme phytoene desaturase, which converts phytoene into lycopene. Lu et al. [17] suggested that transgenic cauliflower with *Or* transgene is associated with a cellular process that triggers the differentiation of proplastids into chromoplasts for carotenoid accumulation and *Or* can be used as a novel genetic tool to induce carotenoid accumulation in a major staple food crops.

One of the most obvious benefits of enhancing carotenoid levels is the increase in pigmentation, which can lead to more deeply colored vegetables that are often preferred by consumers. Thus, increasing levels of carotenoid is doubly beneficial, both in terms of nutrition and esthetics. There are a range of other approaches to enhance the carotenoid levels in potatoes and other root vegetables. Diretto *et al.* [18] have silenced the first step in the ß-epsilon branch of carotenoid biosynthesis, lycopene epsilon cyclase (LCY-e) in potato which is low in carotenoids. This antisense tuber-specific silencing of the gene results in significant increases in carotenoid levels, with up to 14-fold more ß-carotene.

Enhancing anthocyanins: Potato does not normally produce anthocyanin, but germplasm expressing anthocyanin pigment has been developed and is attracting interest from consumers. One of these genes which encode a novel single -domain MYB transcription factor has the potential to influence anthocyanin pigment production in potato. The resulting purple potato might offer both novelty and health functionality to consumers, who can also benefit from native Andean potatoes that do not always show desired tuber shapes for both table and processing industry.

Folates rich tomato: Diaz de la Garza et al. [19] developed transgenic tomatoes by engineering fruit specific over expression of GTP cyclohydrolase I that catalyzes the first step of pteridine synthesis, and amino deoxychorismate synthase that catalyzes the first step of PABA synthesis. Vine ripened fruits contained on average 25 fold more folate than controls by combinig PABA and pteridine overproduction traits through crossbreeding of transgenic tomato plants.

The extent to which vegetable brassicas protect against cancer probably depend on genotype of the consumer, in particular the allele present at the GSTM 1 locus. This gene codes for the enzyme glutathione transferase, which catalyzes the conjugation of glutathione with isothiocyanates. Approximately, 50% of humans carry a deletion on the GSTM1 gene which reduces their ability to conjugate, process and excrete isothiocyanates. Individuals with two null alleles for GSTM1 might gain less protection from these cultivars of vegetable. The most commonly consumed *Brassica* vegetable in Asia is *Brassica rapa*. *B. rapa* contains different isothiocyanates to *B. oleracea* and recent evidence suggests that individuals who are null for GSTM1 can gain a protective benefit from *B. rapa* [20].

A 10 fold increase in the level of 4-methylsulphinylbutyl glucosinolate was obtained by crossing broccoli cultivars with selected wild taxa of the *Brassica oleracea* (chromosome number, n = 9) complex. Tissue from these hybrids exhibited 100 fold increase in the ability to induce quinone reductase in Hepa1cIc7 cells over broccoli cutlivars, due to an increase in 4 – methylsulphinylbutyl glucosinolate content.

Vegetables of the *Allium* genus such as onion, garlic, leek and chive are among the oldest crops associated with health-related properties. Three sets of transgenic onion plants containing antisense alliinase gene constructs (a CaMV 35S-driven antisense root alliinase gene, a CaMV 35S-driven antisense bulb alliinase, and a bulb alliinase promoter-driven antisense bulb alliinase) have been recently produced [21]. Transgenic hybrid onion seed from these transgenic lines has been developed by crossing a nontransgeneic open- pollinated parental line with a transgenic parental plant carrying a single transgene in the hemizygous state.

Miraculin rich vegetables: For reduction of bitterness in lettuce, the gene for sweetness and taste modifying protein miraculin, from the pulp of berries of West African shrub *Richadella dulcifica* was cloned [22]. This gene, with the CaMV 35S promoter, was introduced into the lettue cultivar "Kaiser" using *A. tumefaciens* GV2260. Expression of this gene in transgenic plants led to the accumulation of significant concentrations of the sweet enhancing protein.

Protein rich potato: The genetically modified potato developed at CPRI in collaboration with NIPGAR "Protato" contains 60% enhanced protein content. This has been achieved by introducing *AmA1* gene (*Amaranth Albumin 1*) from edible amaranth plant into seven commercial varieties of potatoes. The GM potato plants were tested in India and the results demonstrated greater harvest and moderate increase in tuber yield. Safety evaluation indicated that the transgenic potatoes are suitable for commercial cultivation and have no negative effects on animal health. In addition, the concentration of several essential amino acids increased significantly in transgenic tubers which are otherwise limited in potato. This resulted in a significant increase in yield and enhanced nutrition. The *AmA1* gene has been reported to have potential for the nutritional improvement of other food crops as well [23].

7. Conclusion

Vegetables are nutritional powerhouses, key sources of micronutrients needed for good health. They add diversity, flavor and nutritional quality to diets.

A strengthened focus on vegetables may be the most direct affordable way to deliver better nutrition for all. Intensified vegetable production has the potential to generate more income and employment than other segments of the agricultural economy, making vegetable an important element of any agricultural growth strategy. Today neither the economic nor the nutritional power of vegetables is sufficiently realized. With a growing understanding of the linkages between dietary quality and health, policy makers must also be prepared to support additional interventions to promote vegetable consumption. Breeding for improved taste, convenience, nutritive value and consumer appeal has already contributed in increase per capita vegetable consumption with the development of products such as baby carrots, yellow and orange peppers, cherry and pear tomatoes, seedless watermelons and lettuces with different with different color, texture and flavor. Therefore conventional breeding in conjunction with molecular biology has bright prospects of developing high yielding vegetable varieties with high neutraceutcials and bio active compounds suitable to offer nutritional security.

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