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Nutraceutical and bioactive healthy compounds in vegetable crops

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Abstract
Nutraceuticals have been successfully applied as sustainable alternatives for the control and prevention of large number of diseases. In day to day life Nutraceuticals have received considerable attention because they are harmless, efficient and have potential nutritional value as well as therapeutic effects. Among natural dietary supplements, vegetables being low in calories are packed with vitamins, minerals, antioxidants and phytochemicals. They play an important role in the human diet and are rich sources of biologically active compounds which are very essential for human beings. Phyto-nutraceuticals include lycopene from tomato, curcumin from turmeric, carotenoids from carrot etc are very popular. Number of studies has proved that vegetables contain more health giving ingredients as sugars, amino acids and vitamins have long been recognized for their health benefits to humans. As technology and research techniques are improving, other substances in vegetables that were previously ignored are getting the spotlight. Another active nutraceutical ingredients in vegetables are flavonoids. They can act as potent antioxidants and metal chelators. They also have long been recognized to possess anti inflammatory, antiallergic, hepatoprotective, antithrombotic, antiviral, and anti carcinogenic activities. Antibacterial activity has been displayed by a number of flavonoids. Flavonoids, especially quercetin, has been reported to possess antidiabetic activity. The potential great number of phytochemicals including some of the vitamins, flavonoids, terpenoids, carotenoids, phenolics, phytoestrogens, minerals and antioxidants in vegetables are used as alternative preservative agents for controlling postharvest physiological disorders or microbial pathogen injuries of vegetables in the food industry. Moreover, these natural compounds have become interesting candidates not only for plant protection but also human and animal health protection from fungal and bacterial diseases because of their lower toxicity or absence of toxicity. The present review will focus on Nutraceutical value of vegetables.

Keywords: Nutraceutical, bioactive healthy, vegetable crops

Introduction
Nutraceuticals are any substance that is a food or a part of a food and provides medical or health benefits, including the prevention and treatment of diseases. The term "Nutraceutical" was coined by combining the terms "Nutrition" and "Pharmaceutical" in 1989 by Dr Stephen De Felice, Chairman of the Foundation for Innovation in Medicine. A product isolated or purified from foods that is generally sold in medicinal forms not usually associated with food. A nutraceutical is demonstrated to have a physiological benefit or provide protection against chronic disease (Gupta *et al*., 2013; Sarin *et al*., 2012) [20, 62]. Vegetables are functional foods nutraceuticals because they provide minerals and nutrients which are health promoting. They play an important part in the human diet and are a major source of biologically active nutraceuticals. It have been explored recently as sustainable alternatives for the control and prevention of large number of diseases. They have received considerable attention because they are safe, efficacious and have potential nutritional value as well as therapeutic effects. Among natural dietary supplements, vegetables being low in calories are packed with vitamins, minerals, antioxidants and phytochemicals. Some popular phyto-nutraceuticals include lycopene from tomato, carotenoids from carrot etc. Such compounds play a role in disease prevention/reduce disease risk factors through antioxidant activity. Functional attributes of many traditional vegetables are being discovered, while new food products are being developed with additional nutraceutic components. Therefore the plant substances important to human nutrition must be clearly identified and should be intend to breed cultivars

with improved nutritional attributes through conventional and molecular breeding approaches (Rai *et al.*, 2012) [58].
Nutraceutical rich vegetables have medical health benefits including the prevention and treatment of diseases (Ramaa *et al.* 2006) [60]. Vegetables are rich sources of bioactive compounds such as flavonoids, carotenoids, anthocyanins, vitamins and other polyphenolics (Hiroyuki *et al.*, 2003) [21]. Such compounds play a role in disease prevention reduce disease risk factors through antioxidant activity. Researchers have identified hundreds of compounds in vegetable crops with functional qualities and they continue to make new discoveries surrounding the complex benefits of phytochemicals such as lycopene in tomatoes, cucumin in turmeric, gingerol in ginger, organosulphur compounds in allium species, omega-3-fatty acids in cucurbitaceous vegetable seeds and so on (Sirtori *et al.*, 2002; Ram *et al.*, 2000; Holman *et al.*, 1998) [64, 59, 22]. The vegetable breeders have been able to boost the nutritional content of certain vegetable crops like vitamin enhanced broccoli and essential amino acids enriched potatoes. There has been an explosion of consumer's awareness regarding the vegetables with physiologically-active specific nutraceuticals. Such products include food supplements, dietary supplements, valueadded processed vegetables as well as non food supplements such as tablets, soft gels, capsules etc (Whitman, 2001; Wildman, 2001) [69, 70].
Herbal medicine is the need of the day. With the modernised, competitive lifestyle and ever increasing stressful conditions, all types of diseases are having a field day. Allopathic cure is available for most of the disorders but it comes at a price. First, the cost of medicine is increasing day by day as for all other commodities. Second, allopathic medicines are associated with a variety of side effects. Therefore, more and more people are inclining towards lifestyle modification and use of herbal products only. This helps in keeping various diseases at bay and
boosting the overall health of the person. Herbal or plant medicine constitutes an effective source of both traditional and modern medicines. It is more popular in rural population and around 80% of rural population in India depends on it for their primary health care. (Israel *et al.*, 2010) [27].
Medicinal plants offer a rich, though inadequately explored, source of components which provide a variety of health benefits. These components, known as phytochemicals, can act as (Dillard *et al.*, 2000) [13].

1. Substrates for various biochemical reactions.
2. Cofactors/ inhibitors of different enzymatic reactions.
3. Absorbents/sequestrants that bind to and eliminate undesirable constituents in the intestine.
4. Ligands that behave as agonists or antagonists of cell surface or intracellular receptors.
5. Scavengers of highly reactive or toxic chemicals.
6. Compounds that enhance the absorption and/ or stability of essential nutrients.
7. Selective growth factors for beneficial gastrointestinal bacteria.
8. Fermentation substrates for useful oral, gastric or intestinal bacteria and selective inhibitors of harmful intestinal bacteria.

Foods containing these phytochemicals are known as 'nutraceuticals'. The term nutraceutical is derived from the words 'nutrition' and 'pharmaceutical'. Thus, nutraceutical is a food or a part of the food which exerts a curative or preventive effect on disease. These include various nutrients, dietary supplements, specially designed diets or herbal products. Nutraceuticals of both plant and animal origin hold great opportunities for food industries to bring out novel food catering to future needs (Kalra EK 2003; Pandey *et al.*, 2010) [28, 51]. The phytochemicals present in these foods have wide range of therapeutic effects against a number of diseases like diabetes, heart disease, common cold, arthritis, cancer, hypertension, dyslipidemia, inflammatory bowel disease, depression etc. Compounds like phenylpropanoids, isoprenoids, polyphenols, anthocynidins, flavonoids, terpenoids, carotenoids, phytoestrogens and alkaloids etc are responsible for the beneficial effects of diet rich in fruits and vegetables. Melatonin (N-acetyl-5 methoxytryptamine) is also found in plant diets which produce kynuramine, a biog enic amine, by oxidative metabolism. Kynuramine improves mitochondrial metabolism, acts as cyclooxygenase2 inhibitor and an important antioxidant (Iriti *et al.*, 2006) [25].
The interface between the nutritional environment and cellular/ genetic processes is termed as 'nutrigenomics'. It provides a molecular enlightenment of phytochemicals benefitting human health by altering the expression or constitution of genes. This leads to alteration in initiation, development and progression of different diseases. Thus, nutrigenomics is very important in the role of nutraceuticals against ageing and different diseases by proving genetic information Prakash *et al.*, 2012 [56].

Emerging trends in nutraceuticals
Nutraceuticals may be divided into herbal/ natural products, dietary supplements and functional foods. Out of these, most rapidly growing segment is herbal/ natural products followed by dietary supplements. The generation of scientific research linked foods of plant origin and health has resulted in understanding that plant bio-active compounds have antioxidant and other health promoting properties. High dietary intake of fibres in the form of fruits, vegetables, whole grains is strongly linked to a reduced risk of chronic diseases like cancer and cardiovascular diseases. Cancer development is a chronic, stepwise complex process culminating into metastsis if not tackled in time. Epidemiological studies now provide convincing evidence that dietary factors may modify carcinogenesis. A number of phytochemicals as well as some plant origin foods with yet unidentified components possess anti-carcinogenic and anti-mutagenic properties. Thus, use of these bioactive compounds as chemopreventive substances, in future can not be overlooked (Cherdshewasart *et al.*, 2009) [8]. Similarly, isoflavonoids or soy products and flaxseed have the abilityto decrease total and low density lipoprotein cholesterol (LDL-C) and increase high density lipoprotein cholesterol (HDL-C) resulting in reduced risk of cardiovascular diseases (CVDs). Phytoestrogens are also reported to be beneficial in prevention of CVDs. For CVD, importantrisk factors include obesity, hyperlipidemia, hypertension and diabetes\ which can be countered by phytochemicals. Phytochemicals help in reducing oxidative stress also which is implicated in process of atherosclerosis. Nutraceuticals help in boosting the antioxidant defense system of the body (Prakash *et al.*, 2011; Prakash and Gupta 2011) [55, 54].

Categories of Nutraceuticals (Craig and Beck 1999) [11].

1. Substances with established nutritional value i.e. nutrients e.g. vitamins, minerals, amino acids, fatty acids, polysaccharides etc.

2. Products of herbs or botanical products in the form of concentrates or extracts i.e. herbals e.g. aloe vera, wheat grass, ginger, garllic etc.
3. Compounds derived from other sources serving specific functions such as sports nutrition, weight-loss supplements and meal replacements termed as dietary supplements.

Nutraceuticals have many beneficial effects; hence, they have been used for treating and prevent many health problems, such as cancer, inflammation, hypertension, cardiovascular diseases, atherosclerosis, obesity, diabetes and others. (Nasri *et al.*, 2014) [48]. Some nutraceuticals, such as silymarin, curcumin, vitamin E, docosahexaenoic acid, choline and phosphatidylcholine are used in treating and preventing steatosis (Stellavato *et al.*, 2018) [66]. Additionally, many nutraceutical products, such as gallic acid, caffeine, curcumin and others act as anti-aging and antioxidant agents (Bourbon *et al.*, 2015; Zhang *et al*., 2019) [5, 73]. PUFA1-rich fish oils reduce the risk of coronary cardiovascular diseases and enhance the brain functions (Liu *et al.*, 2016) [39]. Nutraceuticals are famous for their anticancer efficacy; hence, many nutraceutical ingredients, such as epigallocatechingallate, curcumin, pomegranate and others, treat different types of cancer, such as breast cancer, prostate cancer and other types of cancer. (Hu *et al.*, 2012) [24]. The global spread of nutraceutical products has dramatically increased recently. The main factor that lead to inflating the market share of these products, is that Nutraceuticals have no strict regulations to control them (Nounou *et al.*, 2018) [50]. On the other hand, pharmaceutical products are controlled by strict regulations and are closely monitored. Pharmaceutical products are also strictly regulated and have a governmental sanction (Nasri *et al.*, 2014) [48]. Moreover, nutraceuticals have been advertised under the claim of being safe, effective and being a drug substitute. Additionally, it has been claimed that these products can beused in preventing and treating many health problems without any side effects (Ekor, 2014) [16]. The patients also have been concerned about the use of pharmaceutical products because of their high price and several side effects (Nounou *et al.*, 2018) [50]. Therefore, the market share of nutraceuticals has been tremendously expanded. Approximately 80% of global population preferred dusing dietary supplements and nutraceuticals (Ekor, 2014) [16]. Nutraceutical products now are the fastest growing market\ with an estimated worth of USD 117 billion globally in 2017 (Swaroopa and Srinath 2017) [67].

Classification of Nutraceuticals

Based on food sources, nutraceuticals can be classified as

1. Dietary fibres: These are the plant origin substances present in food which are not digested in gastointestinal tract and add bulk to the intestinal contents. Examples include fruits, barley, oats, lignin, cellulose, pectin etc. Generous intake of these fibres in diet is associated with low risk of CVD, hypertension, diabetes, obesity, and colon cancer and gastrointestinal disorders (Das *et al.*, 2012) [12].

2. Probiotics: These are live microbial feed supplements which when administered in adequate dose help in improving the intestinal microbial balance of the host e.g lactobacilli, bifidobacteria etc. There administration is reported to be associated with a decreased risk of allergy, asthma, cancer, infection of ear and urinary tract (Lenoir –Wijnkoop *et al.*, 2007) [38].

3. Prebiotics: These are the dietary ingredients that benefit the host by selectively altering the composition or metabolism of gut microbiota. These are, generally, fructose based oligosaccharides existing naturally or supplemented in the food and are not digested by human beings. Examples of such foods are chicory roots, banana, tomato and alliums, beans etc. These are found to be beneficial in improving lactose tolerance, detoxification, and dyslipidemia, relief from constipation and in certain tumours (Hord *et al.*, 2012) [23].

4. Polyunsaturated fatty acids: These may be omega 3 fatty acids e.g. α-linolenic acid, eicosapentaenoic acid and docosahexaenoic acid found in fatty fishes, flaxseed, soybean etc. or omega 6 fatty acids e.g. α-linoleic acid and arachidonic acid found in corn, safflower, sunflower and soybean etc(Das *et al.*, 2012) [12].

5. Antioxidant vitamins: These include vitamin C, vitamin E and carotenoids. These vitamins are abundant in many fruits and vegetables and possess singlet oxygen quenching and lipid peroxidation preventing properties. Regular intake of these helps in prevention of a number of diseases (Das *et al.*, 2012) [12].

6. Polyphenols: These phytochemicals are produced by plant for protection against photosynthetic stress and reactive oxygen species e.g flavonoids, anthocyanins and phenolic acids. These possess anti-inflammatory and antioxidant properties and are found in foods like legumes, tea and soybean etc. (Das *et al.*, 2012) [12].

7. Spices: These are esoteric foods adjuncts used to enhance sensory quality of foods. Most of the components of spices are terpenes and other constituents of essential oils. Minute quantities of dietary spices have antioxidant, chemopreventive, antimutagenic, anti-inflammatory amd immune modulatory effects (Kochhar *et al.*, 2008) [30].

Phytochemicals as Neutraceuticals

Phytochemicals are part of a plant’s natural systems of defense and repair. Our bodies utilize a small fraction of these components by incorporating them into various cellular and metabolic processes that enhance cellular growth, regeneration and repair. Some phytochemicals act as antioxidants, some protect and regenerate essential nutrients, and still others work to deactivate cancer-causing substances.

Phytochemicals impart health benefits to humans in addition to those provided by vitamins and minerals alone. Phytochemicals differ from vitamins and minerals in that they are not considered “essential” nutrients, i.e., those which are critical for normal metabolism and growth. With the exception of carotenoids, they are similar to vitamins and minerals in that they are not stored in the body for later use and must be consumed consistently over time (Krishnaswamy and Raghuramulu, 1998) [33]. Perhaps, the most well-known phytochemicals are the antioxidant group, which protect cells from damage caused by the by-products (free radicals) of metabolism, as well as toxic substances in the environment and foods. At high levels, reactive species, such as reactive oxygen and nitrogen species, can be damaging to cells and may contribute to cellular dysfunction and disease. Antioxidants significantly decrease the adverse effects of reactive species by eliminating free radicals as they circulate throughout the body. Beta-carotene and the other carotenoids are not antioxidants, but influence the biochemical reactions involved in the oxidative process. Other phytochemicals include: sulfides (allium), indoles, phytosterols, protease inhibitors, phenols, tannins and terpenes. The phytochemicals can play chemo preventive roles in regards to human cancer by modulation of the cancer cellcycle, proliferation inhibition, and induction of apoptosis (Martin, 2003) [43]. A phytochemical is often found in the coloring agent offruits and vegetables, so eating brighter colored varieties may have benefits. However, there are also several beneficial phytochemicals in colorless or less colorful fruits and vegetables for example, onions and corn are rich in phytochemicals. Based on their chemical structure phytochemical are classified into the ten categories; basically they are subdivided into three main categories i.e. phenolic acids, flavonoids and stilbenes or ligans; these flavonoids are further subdivided into anthocyanins, flavones, flavanones, isoflavones as well as flavonols and flavanols.

Phytochemicals as natural preservatives and antimicrobials

Natural preservatives derived from plant extracts such as phytochemicals and essential oils are used against fungal development in many fruits and vegetables after harvest (Kaur and Kapoor, 2001) [29]. The efficiency of an antimicrobial treatment depends on many factors, such as type, genus, species and strain of the main microorganism, in addition to environmental factors such as pH, water activity, temperature, atmospheric composition and an initial microbial load of the food material. Therefore, other important subject to know is type of the microorganisms owing to usually combinations of antimicrobials is more effective than adding just one. The natural antimicrobial preservative activity is not clear since there are many influencing factors, one of the most important being the interaction between phytochemicals and growth of microorganisms. Processing of foods containing phytochemicals is expected to result in some changes in their phytochemical content. Phytochemicals present in many food stuffs are lost by heat processing such as sterilization, pasteurization and dehydration (Banerjee *et al.,* 2012) [5]. Many investigations have evaluated phytochemical effects on antifungal activity. The potential use of plant extracts as natural antimicrobial agents in food preservation forms the basis for many applications such as grape seed or rosemary extracts that have been used as food preservatives. Flavonoids usually occur as glycosides and aglycones in plant tissue which have significant antioxidant properties and antimicrobial and insect-repellent properties as well. Flavonoids and their antimicrobial effect are useful as a food preservative to extend the shelf life and safety of foods. Flavonoids play important roles in biological activities, including antiallergenic, antiviral and antifungal effects. It is also present in various common fruits and vegetables (apples, grapes, lemons, tomatoes, onions, lettuce and broccoli). The following flavonoids are antifungal agents in plants: isoflavonoids, flavans flavanones (Ismail *et al.,* 2004) [26]. However, the antifungal activity of flavonoid compounds plays an important role between plant-microorganism and host plant's defensive systems. Saponin and flavonoids are found in fruits and vegetables and in general they form a soapy lather after extracted from parts of plants. Thiosulfinates come from hydrolysis products of garlic and onion. They have a strong potential of producing antimicrobial effects against pathogenic microorganisms. Broccoli, Brussels‟ sprouts, cabbage mustard and horseradish have glucosinolates that also have a wide range of antibacterial effects (Ismail *et al.,* 2004) [26].

Phytochemical extraction and determination

All the reagents used were with the analytical grade from Sigma Aldrich, Germany. UV spectrophotometer UV-1800(Shimadzu Corporation, Japan) was used for the absorbance measurements. The chlorophylls, carotenoides and xantophylls were extracted with ethanol according to the methods described by (Krumbein *et al.,* 2005) [34]. with some modifications. Forextraction a representative portion of sample (0.1±0.001 g) (mass) was accurately weighted, grinded and quantitavely transmit in a glass test tube. Then ethanol was added till 5 mL to it and the test tubes were held in dark for 15 minwith occasional shaking at room temperature and finally centrifuged. The chlorophylls, carotenoids and xantophyllscontent were analyzed spectrophotometrically by absorption measurements (A) at 350 to 700 nm with 1 nm interval and calculated according to the following equations:

Chlorophyll a (mg g-1) = 13.7 A 665 – 5.76 A 649 / mass. 200

Chlorophyll b (mg g-1) = 25.8 A 649–7.6 A 665/ mass. 200

Carotenoid (mg g-1) = 4.7 A 440– 0.263 Cchla + chlb/ mass. 200

Xanthophyll – Lutein (mg g-1) = 11.51 A 480– 20.61 A 495/ mass. 200

Beneficial properties of plant phytochemicals

In the last decade, the results of many researches have shown the positive effects of phytochemicals in human health. There is a strong correlation of antioxidant consumption with lower risk of many diseases such as cardiovascular cancer, diabetes and hypertension diseases as well as other medical conditions. Vegetables have phenolic compounds, pigments and natural antioxidants; these compounds protect many diseases like cancer and heart diseases (Kopsell *et al.,* 2005) [31]. The importance of antioxidant effects on cardiovascular diseases and cancer is especially important and these antioxidants can be found in various fruits, vegetables and herbs. Phenolics as flavonoids have important effects such as antimicrobial, anti inflammatory, antioxidant, antiviral, antiallergic, anticancer, a ntiulcer, antidiabetic, antiplasmodial, antihypertensive, anticonvulsant and all reducing risks for severe human diseases(Zhang and Hamauzu, 2004) [72]. Antioxidants in fruits and\ vegetables have defensive effects and are three main groups: vitamins, phenolics and carotenoids. Vitamin C (ascorbic acid, AA) and the oxidized form (dehydroascorbic acid, DHAA), carotenoids and phenolic compounds prevent cardiovascular disease, cancer and cataracts which are associated with the oxidative damage of lipids, DNA and proteins. Moreover, some carotenoids also have antioxidant activity (AOA) and shown beneficial effects on thereduction of cardiovascular diseases. The vegetables that have phytochemicals are also not only low in fat and saturated fat, cholesterol and calories but also are rich in potassium and sodium, fiber, folic acid and AA. One of the most important flavonols is quercetin, which is higher in onion (red and yellow), broccoli, kale, French beans, apple, red grapes and cherries. Quercetin is anticarcinogenic and inhibits low-density lipoprotein (LDL) oxidation activities (Pellegrini *et al.,* 2010) [52].

Nutraceuticals/Phytochemicals/Pigments in Vegetables
Carotenoids for Colon Cancer

Carotenoids are a major class of secondary metabolites with many biological activities such as free radical scavenging properties, skin tone improvement and potential for cancer treatment. Generally carotenoids are classified into two main subclasses such as hydrocarbon carotenoids including *β*-carotene, *α*-carotene, lycopene and oxycarotenoids which include lutein and zeaxanthin, as well as other compounds. Carotenoids have many applications in the clinical and commercial fields. *β*-Carotene has been shown to be efficient in controlling cellular damage from free radicals. Secondary metabolites can influence and effectively react with free radicals in the inner part of the cell membrane. The natural compounds have been more effective in maintaining membrane integrity and antimutagenic properties (Slattery *et al.*, 2000) [65]. The unsaturated nature of lycopene has potential efficiency to provide free radical scavenging activity and inhibit cancer progression.

Lycopene is present in various dietary sources such as tomatoes, grapes and papaya. Carotenoids are used for theprevention of colon and gastrointestinal cancer (Miller *et al.*, 2002) [45]. Other phytochemicals such as xanthophyll, astaxanthin, cryoptoxanthinand zeaxanthin metabolites have been used for the treatment of colon cancer.

Antioxidant Vitamins

Vitamins like vitamin C, vitamin E and carotenoids are collectively known as antioxidant vitamins. These vitamins act both singly as well as synergistically for the prevention of oxidative reactions leading to several degenerative diseases including cancer, cardiovascular diseases, cataracts etc (Elliot, 1999) [17]. These vitamins are abundant in many fruits and vegetables and exert their protective action by free-radical scavenging mechanisms. Vitamin E and selenium has a synergistic role against lipid peroxidation. Vitamin C, better known as ascorbic acid donates hydrogen atom to lipid radicals, quenches singlet oxygen radical and removes molecular oxygen.

Carotenoids

Carotenoids are lipid-soluble, yellow–orange–red pigments found in all higher plants and some animals.

Oxy-carotenoids or xanthophylls such as lutein and zeaxanthin and non-oxy carotenoids (hydrocarbon carotenoids) or carotene such as beta carotene and lycopene has been identified among more than 600 carotenoids found in natural sources (Krinsky & Johnson 2005) [32]. Carotenoids can be divided into carotenes containing only carbon and hydrogen, and xanthophylls made up of carbon, hydrogen, and oxygen. Carotenoids owe their name to carrots (*Daucus carota*), and xanthophyll is derived from the Greekwords for yellow and leaf (Mortensen 2006). Among vegetables, carrot is the single major source of β-carotene providing 17% of the total vitamin A consumption (Arscott & Tanumihardjo, 2010) [1]. Apart from β-carotene, root is good sources of various other lipophilic antioxidants like lycopene and lutein. Red coloured carrot is typical to India (Leja *et al.*, 2013) [37].

Lycopene

Being a precursor in the biosynthesis of β-carotene, lycopene can be expected to be found in plants containing β-caroten. The best-known sources of lycopene are tomatoes, watermelon, red cabbage, red peppers, carrot, guava, and pink grapefruit. This red colored pigment was first discovered in the tomato by Millardet in 1876.

Lutein

Lutein is also a very common carotenoid. Commercially, the most interesting source is Aztec marigold (*Tagetes erecta*) in which lutein is primarily found esterified with saturated fatty acids *viz.*, lauric, myristic, palmitic, and stearic acid (Breithaupt *et al.*, 2002) [6]. Lutein provides nutritional support to our eyes and skin. Its antioxidant activity counteracts radical damage. It is found in good amount in green leafy vegetables like broccoli, spinach, kale and lettuce etc.

Phenols

Phenols comprise a large group of phytonutrients with profound importance in preventive medicine. Phenols have protective action against oxidative damage of tissues and inflammation. Flavonoids, anthocyanidines and isoflavones aremajor subclasses under phenolic group. One of the vegetables with a highest content in phenolics is eggplant (*Solanum melongena* L.) (Gajewski *et al*., 2009) [18]. Because of this, eggplant is considered as a model vegetable crop for the improvement of nutraceutical quality. The main phenolic compound of eggplant is chlorogenic acid (CGA), which is anhydroxicinnamic acid with multiple beneficial properties for human health. (Gajewski *et al*., 2009) [18]. CGA has displayed anti-oxidant, anti-carcinogenic, anti-inflammatory, anti-obesity, cardiprotective, neuroprotective, and analgesic effects (Plazas *et al.*, 2013) [53]. The most important of these phenolic compounds inbeans are flavonols quercetin and kaempferol, flavon apigenin and some phenolic acids (e.g.*p*-coumaric acid or ferulicacid).

Anthocyanins

Anthocyanins give rise to the blue–purple–red–orange color of flowers and fruits, in particular, of many plants. The name comes from two Greek words meaning flower and dark blue (and not the blue–green color we usually associate with cyan). The most important source of anthocyanins is grape pomace from wine production. Other important sources are red cabbage, elderberry, black currant, purple carrot, sweet potato, and red radish. Anthocyanin rich vegetables such as purple cauliflower, broccoli and black/purple carrots are gaining popularity due to their enhanced antioxidant activity. Radish and potato extracts have color characteristics very similar to those of Allura red (Shipp & Abdel, 2010) [63].

Flavonoids

The major active nutraceutical ingredients in plants are flavonoids. As is typical for phenolic compounds, they canact as potent antioxidants and metal chelators. They also have long been recognized to possess antiinflammatory, antiallergic, hepatoprotective, antithrombotic, antiviral, and anticarcinogenic activities. The best-described property of almost every group of flavonoids is their capacity to acts as antioxidants. The flavonoids block the Angiotensin-converting Enzyme (ACE) that is responsible for raising blood pressure (Rahal *et al.*, 2014) [57]. Flavonoids are also helpful in protection of the vascular system (Van Dam *et al.*, 2013) [68]. Bioflavonoid, quercetin present in onion and garlic provides the protection against cancer and heart diseases.

Thiosulfonates

Organosulfur phytochemicals in garlic and onions (garlic has more sulfur than onions), includes mercaptocysteines and allylic sulfides (an allyl is a hydrocarbon-sulfur bond), allylic sulfides contribute to the strong odor of garlic. Louis Pasteur in 1858 first noted antibacterial properties of garlic. Later on, in 1932 Albert Schweitzer treated amoebic dysentery in Africa with garlic (Lanzotti, 2006) [36] Propanethial-S-oxide released from cut onions converted to sulfuric acid in eyes causes "burning", cooking garlic & onions destroys the enzyme allinase, preventing formation of beneficial sulfur compounds.

Lipoic Acid

Lipoic acid are antioxidants which can efficiently quench the hydroxyl radicals. They can protect catalase and glutathione, thus helpful in liver detoxification activities. Leafy green vegetables like spinach and broccoli have the highest concentrations of alpha-lipoic acid. It is found in the chloroplasts of the spinach cells. The chloroplasts in the cells produce the energy or glucose in the broccoli. Other green vegetables also contain alpha-lipoic acid, though not in the concentrations found in leafy vegetables. The Linus Pauling Institute at Oregon State University lists peas, broccoli and Brussels sprouts as other vegetables containing alpha-lipoic acid (Drake,2012) [15].

Nasunin

The main natural source of nasunin is the skin of eggplants (Brinjal). It is also found in the purple radish, redturnip, and red cabbage. It is the substance that provides the dark pigment in the fruit of the eggplant. Its job is to protect the eggplant from environmental damage especially from the sun and other radiant sources of energy. The major type of anthocyanin in purple brinjal is nasunin and has the high antioxidant activity (Noda *et al.*, 2000) [49].

Improvement of Nutraceutical Value of Vegetables Biotechnology and Plant Breeding

Biotechnology is a new, and potentially powerful, tool that has been added by most of the multinational private seed sector to their vegetable breeding programs. Transgenic crops, commonly referred to as genetically modified (GM)crops enable plant breeders to bring favorable genes, often previously inaccessible, into elite cultivars, improving their value considerably and offer unique opportuni-ties for controlling insects, viruses and other pathogens, as well asnutritional quality and health benefits. Conven-tional plant breeding that utilizes non-transgenic approaches will remain the backbone of vegetable genetic improve-ment strategies. However, transgenic crop cultivars should not be excluded as products capable of contributing to more nutritious and healthy food.

Improvement of nutritional quality of horticultural crops including nutraceutical value of vegetable crops will be a rewarding activity for plant breeders as we enter the 21st century. In industrialized countries where sufficient food is available to most of the population, there is an increasing realization that nutritious food can play an important role in assuring a healthful life style and that eating is not solely for sustenance and body growth. People are beginning to consume more healthful foods that can alleviate problems related to "diseases of overabundance" and diet-related chronic diseases, such as some types of obesity, heart disease, and certain types of cancer. It is mainly the plant breeders, along with other agricultural researchers and extension services, who have provided the world's population with plentiful food, improved health and nutrition and beautiful landscapes. The strategy of breeding for mineral and vitamin enhancement of vegetables has several complementary advantages. Most breeding and genetic effort has been directed to the crops which already are relatively rich vitamin sources including carrots, sweet potatoes, peppers, tomatoes, squash, pumpkins and melons. To develop commercial varieties of crops with enhanced nutrition, it may be essential to link nutrition to a commercial driver such as yield.

Anthocyanin in Tomato and Red Cabbage

Transgenic approaches have been taken to increase flavonoid levels in tomato fruit by overexpressing either the structural or regulatory genes involved in the biosynthetic pathway. 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* (Mes *et al.*, 2008) [44]. Similarly, the gene Aubergine (*Abg*), which was introgressed from *Solanum lycopersicoides* Dunal, can induce a strong and variegated pigmentation in the peel of tomatoes (Mes *et al.*, 2008) [44]. Furthermore, the recessive gene atroviolacea (*atv*), derived from the interspecific cross with *Solanum cheesmaniae* (L. Riley) Fosberg, has been shown to 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 and have generally shown a higher production of anthocyanins in the peel (Gonzali *et al.*, 2009) [19].

Anthocyanin and B- Carotene in Cauliflower

Purple cauliflower (*Brassica oleracea* var *botrytis*) is a very eye-catching vegetable and available commercially. The purple coloration is due to the accumulation of anthocyanins. Transcriptional regulation of structural genes appears to be a major mechanism by which anthocyanin biosynthesis is regulated in plants. *R2R3 MYB* and basic helix-loop-helix *(bHLH)* transcription factors as well as *WD40* proteins represent the three major families of anthocyanin regulatory proteins (Ludwig &Wessler 1990).An interesting and unique *Purple (Pr*) gene mutation in cauliflower (*Brassica oleracea* var *botrytis*) confers an abnormal pattern of anthocyanin accumulation, giving the striking mutant phenotype of intense purple color in curds and a few other tissues (Chiu *et al.*, 2010) [9]. induces many tissues of the plant, most noticeably the white edible curd and shoot apical meristem, to accumulate high levels of b-carotene, turning them orange. Plants that are heterozygous for *Or* possess bright orange coloration in these tissues and exhibit normal growth, while *Or* homozygous plants produce smaller curds with stunted growth, presumably due to unknown pleiotropic effects.(Lu *et al.*, 2006) [40].

Anthocyanin in Sweet Potato

In sweet potato, no *MYB*, *bHLH*, or *WD40* protein has been reported so far; instead, a MADS-box gene,*IbMADS10*, was recently isolated and suggested to be involved in anthocyanin pigmentation (Lalusin *et al.*, 2006) [35]. Although its involvement in the underground organ is unclear. Mano *et al.* reported the isolation of a new R2R3-type MYB gene, *IbMYB1*, from a purple-fleshed sweet potato cDNA library and its predominant expression in the tuberous roots of purple-fleshed cultivars (Mano *et al*., 2007) [42]. The *IbMYB1* gene is responsible for purple pigmentation in the flesh of tuberous roots of sweet potato.

Lycopene in Tomato

(Mehta *et al*., 2002) expressed a yeast S-adenosylmethionine decarboxylase gene (*ySAMdc; Spe2*) fused with aripening-inducible E8 promoter to specifically increase levels of the polyamines spermidine and spermine in tomato fruitduring ripening. The enhanced expression of the *ySAMdc*gene resulted in increased conversion of putrescine into higher polyamines and thus to ripening-specific accumulation of spermidine and spermine. This led to an increase in lycopene, prolonged vine life, and enhanced fruit juice quality. Lycopene levels in cultivated tomatoes are generally low, and increasing them in the fruit enhances its nutrient value.

Carotenoid in Potato, Sweet Potato and Tomato

(Diretto *et al*., 2006) [14]. have silenced the first step in the beta-epsilon branch of carotenoid biosynthesis, ly-copeneepsilon cyclase (*LCY-e*) in potato—a tuber crop that contains low levels of carotenoids. This antisense tuber-specific silencing of the gene results in significant increases in carotenoid levels, with up to 14-fold more *β*-carotene.

To enhance the carotenoid content and pro-file of tomato fruit, (Romer *et al*., 2000) [61]. produced trans-genic lines containing a bacterial carotenoid gene (*crtI*) encoding the enzyme phytoene desaturase, which converts phytoene into lycopene. Expression of this gene in trans-genic tomato plants of the cultivar "Ailsa Cray" did not elevate total carotenoid levels. However, the *β*-carotene content increased about threefold, up to 45% of the total carotenoid content.

It is very imperative that the nutrients found in many foods, fruits and vegetables are responsible for the well documented health benefits. For example, lutein and zeaxanthin prevent cataracts and macular degeneration; beta-caroteneand lycopene protect the skin from ultraviolet radiation damage; lutein and lycopene may benefit cardiovascular health, and lycopene may help prevent prostate cancer. Because of these and other marked health benefits of these, it must betaken regularly and to reduce the risk factors like high cholesterol, high blood pressure and diabetes. A great diversity of vegetables should be eaten to ensure that individual's diet includes a combination of phytonutriceuticals and to get all thehealth benefits. Regular consumption of a vegetable rich diet has undeniable positive effects on health sincephytonutriceuticals of vegetables can protect the human body from several types of chronic diseases. Cruciferous vegetables, *Allium* sp, tomato, cucurbits, soybean, carrot, okra, underexploited vegetables like lettuce, coleus, sweet potato, yams, moringa, winged bean, basella, horse purslane, cluster bean etc are good sources of bioactive compounds. The molecular genetics and modern biotechnology approaches in conjunction with deciphering the metabolome of a cropplant are powerful tools that will help in specific redesigning of metabolism in food crops to accumulate desired, or close-to-the-desired, levels of a particular phytonutrient. Additional research is needed in many areas to ensure this emerging science continues to be valid and is translated rapidly into consumer-relevant products.

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