Plant Archives Vol. 25, Supplement 2, 2025 pp. 2374-2380 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-2.300

VEGETABLES AS A SOURCE OF NUTRITION AND PHARMACY: A REVIEW

Rajeev Kumar[1*], Aanchal Chauhan[2], Reena Kumari[2], Priyanka Thakur[3] and Neha Thakur[4]
[1]Department of Vegetable Science, College of Horticulture and Forestry Thunag, Mandi, H.P., India
[2]Department Vegetable Science, College of Horticulture, Nauni, Solan, M.P., India
[3]Department of Seed Science & Technology, College of Horticulture, Nauni, Solan, M.P., India
[4]Department of Seed Science & Technology, College of Horticulture & Forestry Thunag, Mandi., H.P., India
*Corresponding author Email: rajeev2287@gmail.com
(Date of Receiving : 13-04-2025; Date of Acceptance : 20-06-2025)

ABSTRACT

Nutraceuticals are naturally occurring bioactive compounds, often responsible for the color, flavor, and health-promoting properties of vegetables. These compounds are synthesized through complex biochemical pathways, regulated by both genetic and environmental factors. Since ancient times, humans have instinctively selected a wide range of vegetable crops both cultivated and wild for their nutritional and therapeutic benefits. Numerous vegetables are rich in health-enhancing phytochemicals such as antioxidants, flavonoids, carotenoids, and polyphenols. The biosynthesis of these compounds is governed by multiple genes, many of which remain unidentified within the vast and diverse germplasm of vegetable crops. India, with its varied agro-climatic zones from tropical to temperate offers a unique opportunity to grow and improve a wide spectrum of vegetable crops across the country. The nation's rich genetic diversity presents immense potential for breeding specialized varieties with enhanced nutraceutical profiles. This review focuses on the nutraceutical potential of vegetables in relation to specific health benefits and diseases, while also exploring advances in biotechnology and molecular breeding aimed at improving the nutritional and functional quality of vegetables. Understanding and harnessing these compounds holds the key to developing next-generation vegetable varieties with significant health-promoting properties.
***Keywords*:** Vegetables, Nutraceuticals, Antioxidants, Functional Foods, Vegetable Breeding, Molecular Approaches

Introduction

Vegetables are among the most accessible and affordable sources of vital nutrients, including carbohydrates, proteins, essential amino acids, dietary fibers, vitamins, and minerals. Their regular consumption significantly lowers the risk of cardiovascular diseases, metabolic disorders, obesity, and gastrointestinal ailments. In addition to their nutritional value, vegetables are rich in phytochemicals bioactive compounds that function as antioxidants, phytoestrogens, and anti-inflammatory agents, thereby playing a crucial role in health promotion and disease prevention.

Recognized as functional foods and nutraceuticals, vegetables contribute significantly to human health by offering physiologically active compounds that support bodily functions and protect against chronic illnesses. Modern research continues to uncover functional properties in both conventional and indigenous vegetables, spurring the development of new food products enriched with nutraceutical components. It is therefore essential to identify key plant-based compounds that benefit human nutrition and focus breeding efforts both conventional and molecular on enhancing these traits (Rai *et al.*, 2012).

Common vegetables such as tomato, carrot, cabbage, broccoli, onion, garlic, and ginger exhibit notable nutraceutical potential. Bioactives like lycopene from tomato, curcumin from turmeric, and carotenoids from carrot are among the many phytochemicals gaining global research attention (Tikunov *et al*., 2010).

Nutraceuticals have emerged as promising natural alternatives for the prevention and management of numerous health conditions. Their appeal lies in their dual role: offering therapeutic effects while being inherently safe and nutritionally valuable. Vegetables, in particular, are low in calories yet rich in antioxidants, vitamins, minerals, and phytochemicals making them indispensable in a balanced diet. While many vegetable-derived nutraceuticals are reputed to offer a wide range of therapeutic benefits, more robust scientific validation is required to substantiate these claims and understand potential side effects.

The term "nutraceutical" a blend of *"nutrition"* and *"pharmaceutical"* was introduced in 1989 by Dr. Stephen De Felice, founder of the Foundation for Innovation in Medicine. He defined nutraceuticals as foods or parts of foods that offer medical or health benefits, including the prevention and treatment of disease (Gupta *et al*., 2013; Sarin *et al*., 2012).

In addition to their health-enhancing compounds, vegetables contribute to culinary diversity and healthful eating. Vegetable salads, for instance, not only offer vibrant colors, fresh textures, and appealing flavors but also aid in weight management, digestive health and satiety (Ello-Martin *et al*., 2005). They help prevent constipation, regulate blood sugar and cholesterol levels, and support optimal gastrointestinal function (Azadbhakt *et al*., 2012). Furthermore, vegetables boost immunity, reduce oxidative stress, and help mitigate the harmful effects of environmental contaminants (Logendra *et al*., 2002; Gibson *et al*., 2012; Gagné *et al*., 2013).

In light of growing interest in natural health solutions, vegetables hold immense promise as sustainable, effective, and accessible nutraceutical resources.

Phytonutrients and Nutraceuticals from Vegetables

Phytonutrients, naturally occurring compounds found in vegetables, are classified based on their similar protective functions and distinct physical and chemical properties. These bioactive substances are essential for maintaining health and preventing disease. A balanced intake of various phytonutrient classes is crucial for holistic well-being. As nutraceuticals, these compounds open avenues for innovative therapeutic applications and preventive healthcare. Below is an overview of key phytonutrients and their significant medicinal roles:

Anthocyanins

Anthocyanins, flavonoid pigments responsible for red, purple, blue, and orange hues in fruits and vegetables, offer potent health benefits. They inhibit cyclooxygenase enzymes, thereby impeding carcinogenesis initiation, and exert a protective effect on pancreatic cells while moderating glucose absorption. Anthocyanins also enhance visual function, including night vision, and strengthen connective tissue through collagen cross-linking. Their antioxidant activity helps neutralize free radicals and reduces myocardial infarction risk (Cassidy *et al*., 2013; Al-Sane & Perata, 2011).

Carotenoids

Carotenoids encompassing carotenes and xanthophylls are the second most abundant pigments in nature, with over 700 identified members (Britton, 1998). Found in tomatoes, spinach, and citrus fruits, they include alpha, beta, gamma, and epsilon carotene, lycopene, and lutein. Beta-carotene exhibits the highest vitamin A activity, while other forms offer tissue-specific antioxidant and anticancer benefits (Yoon *et al*., 2012). Carotenoids protect against various cancers, enhance immune function, support vision, guard skin from UV damage, and aid in detoxifying harmful compounds (Mahima *et al*., 2014).

Betalains

Betalains, natural pigments used historically for coloration, are gaining popularity as safe, plant-based food colorants due to their strong antioxidant properties and free radical scavenging potential.

Chlorophylls

Chlorophylls are essential green pigments known for their chemopreventive properties. Diets rich in green leafy vegetables ensure substantial chlorophyll intake, which has demonstrated anti-mutagenic activity and potential in cancer prevention (Chakraborty *et al*., 2010).

Catechins

Catechins, a unique class of flavonoids, are abundant in green tea (*Camellia sinensis*) and exhibit powerful antioxidant and chemo-preventive actions (Scoparo *et al*., 2012).

Flavonoids

This diverse subclass of phenolic compounds enhances vitamin C activity and acts as a robust antioxidant. Found in kale, broccoli, citrus, onion, and beetroot, flavonoids combat allergies, inflammation, viral infections, cancer, ulcers, and liver disorders. They inhibit angiotensin-converting enzyme (ACE), reduce platelet aggregation, and protect against estrogen-induced cancers. Their role in vascular health and cataract prevention is notable (Dam *et al.*, 2013).

Glucosinolates

Abundant in cruciferous vegetables, glucosinolates stimulate liver detoxification enzymes and enhance immune responses. Their hydrolysis products, such as isothiocyanates and sulforaphane, block enzymes involved in carcinogenesis of liver, lung, breast, and gastrointestinal tissues (Baskar *et al.*, 2012).

Indoles

Indoles interact with vitamin C to detoxify chemical carcinogens and promote the formation of protective biotransformation products like ascorbigen in the stomach.

Isoflavones

Common in soybeans and legumes, isoflavones (e.g., genistein and daidzein) inhibit tumor-promoting enzymes and are linked to lower incidences of breast, uterine, and prostate cancers in populations consuming soy-rich diets (Kaufman *et al.*, 1997).

Isoprenoids

Isoprenoids scavenge free radicals and stabilize lipid membranes by transferring reactive species to other antioxidants.

Limonoids

Present in citrus peels, limonoids protect lung tissue and prevent hormone-related breast cancers. Their anticarcinogenic effects stem from the activation of liver detoxification pathways (Kim *et al.*, 2012; Sun *et al.*, 2013).

Lipoic Acid and Ubiquinone (Coenzyme Q10)

These versatile antioxidants neutralize hydroxyl radicals and operate in both lipid and aqueous environments. They regenerate vitamins C and E and support liver detoxification by protecting catalase and glutathione.

Phytosterols

Found in green and yellow vegetables and seeds, phytosterols lower cholesterol absorption in the intestines, reducing cardiovascular disease risk. They also exhibit anticancer potential, particularly in the colon, breast, and prostate (Jones *et al.*, 1997; Awaisheh *et al.*, 2013).

Phenols

Phenolic compounds offer strong protection against oxidative stress, inflammation, and blood clotting. They contribute to the pigmentation of berries, grapes, and eggplant, and inhibit pro-inflammatory enzymes and platelet aggregation.

Terpenes

This largest group of phytonutrients includes carotenoids like beta-carotene. Terpenes safeguard bodily fluids from oxidative damage and are prevalent in green vegetables, soy, and grains.

Thiols

Sulfur-rich thiols in garlic, onions, and cruciferous vegetables possess anticarcinogenic, antimicrobial, and cardiovascular benefits. They support liver detoxification and inhibit tumor and microbial growth.

Tocotrienols and Tocopherols

Both occurring naturally in grains and palm oil, tocotrienols inhibit breast cancer cell proliferation, while tocopherols (vitamin E forms) help lower cholesterol levels.

Enhancing Nutraceutical Content in Vegetables

The fresh fruit and vegetable sector plays a vital role in the global economy, with the market for nutraceuticals and functional foods witnessing rapid and sustained growth. Key nutraceuticals such as vitamins C and E, and carotenoids are known for their potent antioxidant properties and their preventive effects against various chronic conditions, including cardiovascular diseases and certain types of cancer (Scheerens, 2001).

To meet the growing consumer demand for health-promoting foods, there is an increasing need to enhance the nutraceutical value of fresh produce. Improving the health benefits of vegetables not only supports public well-being but also adds commercial value, opening up new market opportunities for growers and processors especially in health-conscious segments.

Achieving this objective requires the adoption of innovative technologies and strategies aimed at maximizing the concentration and bioavailability of desirable phytonutrients. Two primary approaches for enhancing nutraceutical content in vegetables include:

- **Induction of Controlled Abiotic Stress:** Strategically applied environmental stresses (e.g., light, temperature, or water regulation) can stimulate plants to increase the synthesis of certain bioactive compounds.
- **Conventional and Molecular Breeding:** Through selective breeding and modern genetic techniques,

new vegetable varieties can be developed with inherently higher levels of targeted nutraceuticals.

By integrating these methods, the vegetable industry can deliver high-quality produce with elevated health benefits, catering to evolving consumer preferences and strengthening the functional food supply chain.

Controlled Abiotic Stress and Enhancement of Nutraceuticals in Vegetables

Controlled abiotic stress represents a promising strategy for enhancing the nutraceutical profile of fresh produce. Treatments such as temperature fluctuations, ultraviolet (UV) light exposure, mechanical wounding, phytohormone application, altered atmospheric composition, heat shock, and water stress can significantly influence secondary metabolism in plant tissues. These stresses can stimulate the synthesis of beneficial phytochemicals with nutraceutical activity, while in some cases reducing the production of undesirable compounds.

Abiotic stresses primarily affect the biosynthesis of three major classes of secondary metabolites: terpenes**,** phenolics, and nitrogen-containing compounds**.** The accumulation or degradation of these bioactive compounds is often linked to changes in enzymatic activities within secondary metabolic pathways (Dixon and Paiva, 1995). Harnessing these stress responses offers valuable opportunities to the fresh produce industry for enhancing the health-promoting properties of both fresh-cut and whole vegetables. Similarly, the food processing and nutraceutical industries can apply such techniques to improve the quality and potency of processed products.

Pre-harvest abiotic stress has shown considerable promise in enhancing crop quality. For example, increased light exposure and reduced irrigation frequencies have been reported to elevate vitamin C levels in produce (Lee and Kader, 2000). Water stress has been shown to increase the pungency of pepper fruits (Estrada *et al*., 1999). Such controlled field stresses can be used to optimize phytochemical content before harvest.

Post-harvest stress treatments also offer potential to modify phytochemical profiles in plant tissues. Ripening stage and storage temperature are known to influence anthocyanin accumulation in fruits such as blackberries, strawberries, and apples, as well as in colored potatoes (Lewis *et al*., 1999). Mechanical wounding has been demonstrated to stimulate phenolic acid and anthocyanin synthesis in red lettuce (Ferreres *et al*., 1997) and phenolic compounds in carrots (Babic *et al*., 1993). Similarly, phytohormones like ethylene can induce phenolic accumulation in carrots (Lafuente *et al*., 1996). Light exposure enhances chlorogenic acid levels in potatoes (Li *et al*., 2003) and anthocyanin accumulation in red cabbage (Craker and Wetherbee, 1972).

The use of controlled post-harvest stresses can further unlock the genetic potential of vegetables to yield products with enriched health benefits. For instance, methyl jasmonate treatment has been found to boost anthocyanin content in purple-fleshed potatoes (Reyes *et al*., 2001) and modulate phenolic profiles in purple carrots while preventing the accumulation of undesirable isocoumarin phytoalexins (Heredia *et al*., 2001). Wounding has also been shown to enhance antioxidant capacity in lettuce (Kang and Saltveit, 2002).

However, it is crucial to acknowledge that abiotic stresses are not universally beneficial. In certain cases, they may lead to the degradation of desirable compounds or induce the synthesis of undesirable ones. For example, heat stress can result in chlorophyll loss in broccoli and may inhibit phenolic synthesis in lettuce (Velarde and Saltveit, 2001). Water stress can reduce ascorbic acid levels in leafy greens (Lazan *et al*., 1987). Moreover, ethylene exposure has been linked to the formation of bitter compounds such as isocoumarin in carrots (Lafuente *et al*., 1996) and xanthotoxin in parsnips (Schattuck *et al*., 1988).

In summary, while controlled abiotic stress is a powerful tool to enhance the nutraceutical quality of vegetables, its application must be carefully optimized to maximize benefits and minimize negative outcomes.

Breeding Approaches for Enhancing Nutraceuticals in Vegetables

Breeding strategies offer significant potential to enhance the nutraceutical composition of vegetable crops. Both conventional and molecular breeding approaches are widely utilized to improve levels of bioactive compounds and health-promoting traits.

In conventional breeding, methods such as genotype screening and selection, backcrossing, and mutation breeding are effectively used to incorporate favorable traits related to nutraceutical content. These techniques facilitate the development of improved vegetable cultivars with elevated levels of vitamins, antioxidants, and edible pigments.

Advancements in molecular biology and genetic engineering have further accelerated the process through marker-assisted selection (MAS) and transgenic approaches. Marker-assisted breeding enables precise integration of genes linked to nutraceutical traits, while transgenic methods allow the introduction of novel genes for the synthesis or enhancement of targeted phytochemicals. Together, these approaches provide a powerful platform for the development of next-generation vegetables enriched with nutraceutical properties.

Breeding Techniques

The choice of breeding method is largely determined by the crop's reproductive biology and the genetic architecture governing the trait of interest. Factors such as additive genetic variance, dominance, and epistasis influence the effectiveness of a breeding strategy. Efficient breeding methods should aim to select favorable gene combinations, maximize additive variance, exploit heterosis, and ensure a strong correlation between expected genetic gain and realized improvements.

F_1 hybrid development is especially promising for nutraceutical enhancement. For instance, significant increases in β-carotene content have been reported in F_1 hybrids of muskmelon (Moon *et al.*, 2002).

Key Achievements Through Breeding

Orange Cauliflower (Or gene):

A single-locus, semi-dominant mutation in the *Or* gene of *Brassica oleracea* var. *botrytis* leads to β-carotene accumulation in plant tissues, producing orange-colored curds. Homozygous plants show intense pigmentation, while heterozygous ones exhibit commercial-grade curds. The *Or* gene is believed to function by creating a carotenoid sink rather than directly regulating carotenogenesis (Li & Garvin, 2003).

Orange Cucumber (Ore gene):

The *Ore* gene, introgressed from *Xishuangbanna* gourd into cucumber, enables accumulation of up to 700 µg of β-carotene per 100 g of fresh weight in the orange-colored mesocarp. This provides a valuable genetic resource for provitamin A enhancement (Bo, 2012).

Purple Cauliflower (Pr gene):

The *Pr* gene, encoding a MYB transcription factor, regulates ectopic anthocyanin accumulation in *Brassica oleracea*. This leads to intense purple pigmentation in curds and certain vegetative tissues. Transgenic studies confirmed the gene's role in activating structural genes involved in flavonoid biosynthesis (Chiu *et al.*, 2010).

High-Glucosinolate Broccoli:

Crossing *Brassica villosa*, a wild relative rich in 3-methylthiopropyl glucosinolate, with cultivated broccoli led to F_1 hybrids with elevated levels of 4-methylsulphinylbutyl glucosinolate (sulforaphane precursor). These compounds have strong anti-carcinogenic properties (Sarikamis *et al.*, 2006; Faulkner *et al.*, 1998).

Protein-Rich Potato (AmA1 gene):

The *AmA1* gene from *Amaranthus* was introduced into potato, resulting in a GM variant known as the "Protato." It contains 60% more protein and increased levels of essential amino acids such as lysine, tyrosine, and sulfur-containing amino acids (Chakraborty *et al.*, 2010).

Anthocyanin-Rich Tomato (Aft & Atv genes):

Anthocyanin accumulation was achieved in tomato through interspecific crosses involving *S. chilense* (Aft gene) and *S. cheesmaniae* (Atv gene). These pigments offer antioxidant and protective functions under environmental stress while providing therapeutic benefits to human health.

Nutraceutical and Phytochemical-Rich Varieties

Several Indian varieties developed with enhanced nutraceutical content include:

- **Carrot:** Pusa Asita (Anthocyanin), Pusa Rudhira (Lycopene), Pusa Nayanjyoti (β-carotene)
- **Radish:** Pusa Jamuni (Anthocyanin), Pusa Gulabi (Lycopene)
- **Red Cabbage:** Red Acre (Anthocyanin)
- **Bitter Gourd:** Pusa Aushadhi (β-carotene), Pusa Vishesh, Pusa Hybrid-2 (Calcium & Iron)
- **Tomato:** Pusa Uphar, Pusa Rohini, Pusa Hybrid-2, Pusa Red Plum (Vitamin C & Lycopene)

Conclusion

Nutraceuticals are gaining recognition as sustainable alternatives for disease prevention and health promotion. Vegetables, being nutrient-dense and low in calories, are a rich source of vitamins, minerals, antioxidants, and phytochemicals. Compounds such as lycopene (tomato), curcumin (turmeric), and carotenoids (carrot) have shown potential therapeutic effects including anti-inflammatory, antioxidant, and anticancer properties.

Despite the promise, more research is needed to validate their health claims and ensure safety. Nonetheless, the integration of advanced breeding techniques with conventional approaches offers immense potential for developing vegetable crops tailored for health-conscious markets and improving global nutritional security.

References

Al-sane, Perata (2011). Anthocyanins and anthocyanin tomato mutants: an overview. *Plant Biosyst.*, 145: 436–444.

Awaishesh, S.S., Khalifeh, M.S., Al-Ruwaili, M.A., Khalil, O.M., Al-Ameri, O.H., Al-Groom, R. *et al*. (2013). Effect of supplementation of probiotics and phytosterols alone or in combination on serum and hepatic lipid profiles and thyroid hormones of hypercholesterolemic rats. *J. Dairy Sci.*, **96:** 9–15.

Azadbhakt, L., Haghighadoost, G. and Karimi Esmaillzadeh, A. (2013). Effect of consuming salad and yogurt as preload on body weight management and cardiovascular risk factors: a randomized clinical trial. *Int. J. Food Sci. Nutr.*, **64(4):** 392–399.

Babic, I., Amoit, M.J., Nguyen-The, C. and Aubert, S. (1993). Accumulation of chlorogenic acid in shredded carrots during storage in an oriented polypropylene film. *J. Food Sci.*, **58:** 840–841.

Baskar, V., Gururani, M.A., Yu, J.W. and Park, S.W. (2012). Engineering glucosinolates in plants: current knowledge and potential uses. *Appl. Biochem. Biotechnol.*, **168:** 1694–1717.

Bo, Kailang (2012). Inheritance and mapping of the ore gene controlling the quantity of β-carotene in cucumber (*Cucumis sativus* L.) endocarp. *Mol. Breed.*, **30(1):** 335–344.

Britton, G. (1998). Overview of carotenoid biosynthesis. In: *Carotenoids*, Birkhauser, Basel, Switzerland, 13–147.

Cassidy, A., Mukamal, K.J., Liu, L., Franz, M., Eliassen, A.H., Rimm, E.B. *et al*. (2013). Intakes of anthocyanins and flavones are associated with biomarkers of insulin resistance and inflammation in women. *J. Nutr.*, **144(2):** 202–208.

Chakraborty, S., Chakraborty, N., Agrawal, L., Ghosh, S., Narula, K., Shekhar, S. *et al*. (2010). Next generation protein-rich potato by expressing a seed protein gene AmA1 as a result of proteome rebalancing in transgenic tuber. *Proc. Natl. Acad. Sci. USA*, **107(41):** 17533–17538.

Chiu, L.W., Zhou, X., Burke, S., Wu, X., Ronald, P.L., Li, L. *et al*. (2010). The Purple Cauliflower Arises from Activation of a MYB Transcription Factor. *Plant Physiol.*, **154(3):** 1470–1480.

Craker, L.E. and Wetherbee, P.J. (1972). Ethylene, light and anthocyanin synthesis. *Plant Physiol.*, **49:** 20–20.

Dam, V.R.M., Naidoo, N. and Landberg, R. *et al*. (2013). Dietary flavanoids and the development of type 2 diabetes and cardiovascular diseases: review of recent findings. *Curr. Opin. Lipidol.*, **24:** 25–33.

Delgado-Vargas, F. and Paredes-Lopez, O. (eds.) (2003). *Natural Colorants for Food and Nutraceutical Uses*. CRC Press, Florida, USA. Dixon, R.A. and Paiva, N.L. (1995) Stress induced phenylpropanoid metabolism. *Plant Cell*, **7:** 1085–1097.

Ello-Martin, J.A., Ledikwe, J.H. and Rolls, B.J. (2005). The influence of food portion size and energy density on energy intake: implications for weight management. *Am. J. Clin. Nutr.*, **82:** 2365–2415.

Estrada, B., Pomar, F., Diaz, J., Merino, F. and Bernal, M.A. *et al*. (1999). Pungency level in fruit of the Padron pepper with different water supply. *Sci. Hortic.*, **81:** 385–396.

Faulkner, K., Mithen, R. and Williamson, G. *et al*. (1998). Selective increase of the potential anticarcinogen 4-methylsulphinylbutyl glucosinolate in broccoli. *Carcinogenesis*, **19(4):** 605–609.

Ferreres, F., Gil, M.I., Castaner, M. and Toman-Barberan, F.A. (1997). Phenolic metabolites in red pigmented lettuce (*Lactuca sativa*): changes with minimal processing and cold storage. *J. Agric. Food Chem.*, **45:** 4249–4254.

Gagne, D., Lauziere, J., Blanchet, R., Vezina, C., Vaissiere, E., Ayotte, P. and Obrien, H.T. (2013). Consumption of tomato products is associated with lower blood mercury level in Inuit preschool children. *Food Chem. Toxicol.*, **51:** 404–410.

Gibson, A., Adgar, J.D., Neville, C.E., Gillchrist, S.E. and McKinley, M.C. *et al*. (2002). Effect of fruit and vegetable consumption on immune function in older people: a randomized controlled trial. *Am. J. Clin. Nutr.*, **96:** 1429–1436.

Gupta, S.K., Yadav, S.K., Patil, M.S.M. *et al*. (2013). Nutraceutical–a bright scope and opportunity of Indian healthcare market. *Int. J. Res. Dev. Pharm. Life Sci.*, **2(4):** 478–481.

Heredia, J.B., Loaiza, J.G. and Cisneros-Zevallos, L. (2001). Phenolic synthesis in maroon carrots treated with ethylene and methyl jasmonates stored at different temperatures. *Proc. IFT Annu. Meet.*, **27:** 90–90.

Jones, P.J., MacDougall, D.E., Ntanios, F. and Vanstone, C.A. (1997). Dietary phytosterols as cholesterol-lowering agents in humans. *Can. J. Physiol. Pharmacol.*, **75:** 217–227.

Kalt, W., Howell, A., Duy, J.C., Forney, C.F. and McDonald, J.E. *et al*. (2001). Horticultural factors affecting antioxidant capacity of blueberries and other small fruit. *HortTechnology*, **11:** 523–528.

Kang, H.M. and Saltveit, M.E. (2002). Antioxidant capacity of lettuce leaf tissue increases after wounding. *J. Agric. Food Chem.*, **50:** 7536–7541.

Kaufman, P.B., Duke, J.A., Brielmann, H., Boik, J. and Hoyt, J.E. (1997). A comparative survey of leguminous plants as sources of the isoflavanones, genestein and daidzein: implications for human nutrition and health. *J. Altern. Compl. Med.*, **3:** 7–12.

Kim, J., Jayaprakasha, G.K. and Patil, B.S. (2012). Limonoids and their anti-proliferative and anti-aromatase properties in human breast cancer cells. *Food Funct.*, **4:** 258–265.

Lafuente, M.T., Lopez-Galvez, G., Cantwell, M. and Yang, S.F. (1996). Factors influencing ethylene induced isocoumarin formation and increased respiration in carrots. *J. Am. Soc. Hortic. Sci.*, **121:** 537–542.

Lazan, H., Ali, Z.M., Mohd, A. and Nahar, F. (1987). Water stress and quality decline during storage of tropical leafy vegetables. *J. Food Sci.*, **52:** 1286–1292.

Lee, S.K. and Kader, A.A. (2000). Preharvest and postharvest factors influencing vitamin C content of horticultural crops. *Postharvest Biol. Technol.*, **28:** 207–220.

Lewis, C.E., Walker, J.R.L. and Lancaster, J.E. *et al*. (1999). Changes in anthocyanin, flavonoids and phenolic acid concentration during development and storage of coloured potato (*Solanum tuberosum* L.) tubers. *J. Sci. Food Agric.*, **79:** 311–316.

Li, L. and Garvin, D.F. (2003). Molecular mapping of *Or*, a gene inducing β-carotene accumulation in cauliflower (*Brassica oleracea* L. var. *botrytis*). *Genome*, **46:** 588–594.

Logendra, L.S., Gilrain, M.R., Gianfagna, T.J. and Janes, H.W. (2002). Swiss chard: a salad crop for space programme. *Life Support Biosph. Sci.*, **8:** 173–179.

Mahima, R.A., Verma, A.K., Amit, K., Tiwari, R., Kapoor, S. *et al*. (2014). Phytonutrients and nutraceuticals in vegetables and their multi-dimensional medicinal and health benefits for humans and their companion animals: a review. *J. Biol. Sci.*, **14(1):** 1–19.

Moon, S.S., Verma, V.K. and Munshi, A.D. (2002). Gene action of quality traits in muskmelon (*Cucumis melo* L.). *Veg. Sci.*, **29(2):** 134–136.

Rai, S.K., Arora, N., Pandey, N., Meena, R.P., Shah, K. and Rai, S.P. (2012). Nutraceutical enriched vegetables: molecular approaches for crop improvement. *Int. J. Pharm. Bio Sci.*, **3(2):** 363–379.

Reyes, L., Loaiza, J. and Cisneros-Zevallos, L. (2001). Effect of ethylene, methyl jasmonate and temperature on the synthesis of anthocyanin in colored-flesh potatoes. *Proc. IFT Annu. Meet.*, **23–27:** 245–246.

Sarikamis, G., Marquez, J., MacCormack, R., Bennett, R.N., Roberts, J. and Mithen, R. (2006). High glucosinolate broccoli: a delivery system for sulforaphane. *Mol. Breed.*, **18(3):** 219–228.

Sarin, R.S.M., Manisha, S., Robin, S., Sunil, K. *et al*. (2012). Nutraceuticals – A review. *Int. Res. J. Pharm.*, **3(4):** 95–99.

Schattuck, V.I., Yada, R. and Lougheed, E.C. *et al*. (1988). Ethylene induced bitterness in stored parsnips. *HortScience*, **23:** 912–912.

Scheerens, J.C. (2001). Phytochemical and the consumer: factors affecting fruit and vegetable consumption and the potential for increasing small fruit in the diet. *HortTechnology*, **11:** 547–556.

Scoparo, C.T., de Souza, L.M., Dartora, N., Sassaki, G.L., Gorin, P.A. and Iacomini, M. *et al*. (2012). Analysis of *Camellia sinensis* green and black tea via ultra-high performance liquid chromatography assisted by liquid-liquid partition and two-dimensional liquid chromatography. *J. Chromatogr.*, **1222:** 29–37.

Sun, K.H., Ahn, Y.O., Ahn, M.J., Jeong, J.C., Lee, H.S., Kwak, S.S. *et al*. (2013). Cloning and characterization of an *Orange* gene that increases carotenoid accumulation and salt stress tolerance in transgenic sweet potato cultures. *Plant Physiol. Biochem.*, **70:** 445–454.

Tikunov, Y.M., de Vos, R.C.H., Parmas, A.M.G., Hall, R.D. and Bovy, A.G. (2010). A role of differential glycoconjugation in the emission of phenylpropanoid volatiles from tomato fruit discovered using a metabolic data fusion approach. *Plant Physiol.*, **152:** 55–70.

Velarde, L.J.G. and Saltveit, M.E. (2001). Heat shocks applied either before or after wounding reduce the browning of lettuce leaf tissue. *J. Am. Soc. Hortic. Sci.*, **126:** 227–234.

Yoon, G.A., Yenum, K.J., Cho, Y.S., Chen, C.Y. and Tang, G. *et al*. (2012). Carotenoids and total phenolic contents in plant food commonly consumed in Korea. *Nutr. Res. Pract.*, **6:** 481–490.