Preharvest Factors Affecting Postharvest Quality of Vegetables

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Postharvest quality of fresh vegetables generally depends on the quality achieved at time of harvest. Vegetable quality is influenced by a plethora of preharvest factors and combinations of factors that include genetic and environmental components (Beverly et al., 1993; Salunkhe et al., 1991). The effects of preharvest factors on postharvest quality impact individual plants and plant communities and were recently reviewed by Beverly et al. (1993) and Salunkhe et al. (1991). Although limited information is available about preharvest management effects on postharvest quality of vegetables as compared to fruit, these authors described the impact of cultural practices on the quality of vegetable and plant products. To avoid being repetitive, we will focus on pertinent and recent examples of how physiological processes and field management strategies influence the ultimate quality of harvested vegetables.

The successful production, quality, and nutritional value of horticultural commodities is closely related to the production of chlorophylls, carotenoids, xanthophylls, and other chemicals, as well as photosynthesis and the formation of complex carbohydrates. Respiration, transpiration, and the formation of other chemical and flavor components in maturing fruit often depend on cultivar, the environment, and cultural factors (Hulme, 1970; Kader, 1987). We will discuss specifically how climatic conditions, cultural practices, harvest maturity, and genetics influence the quality and nutritional value of vegetables.

CLIMATIC CONDITIONS

Climatic factors have been shown to have an important influence on the quality and nutritional value of vegetables. We will not focus on the effects of light quality and availability on photosynthesis and respiration in higher plants, since this is covered in great detail in the literature of vegetable and fruit crops. However, we will discuss, in particular, temperature, light intensity, and water availability, which are determinants of vegetable quality and ascorbic acid, carotene, thiamin, and riboflavin content (Beverly et al., 1993; Harris, 1975; Kader, 1987).

Light intensity. Light intensity can have profound effects upon crop yield and quality over the course of time. In general, the lower the light intensity, the lower the content of ascorbic acid in plant tissues (Kader, 1987). Ascorbic acid concentration also generally increases with increased exposure to light, particularly in leafy greens (Nagy and Wardowski, 1988; Shewfelt, 1990). Light has also been shown to be required for the formation of β -carotene in tomatoes (*Lycopersicon esculentum* Mill.) (Raymundo et al., 1976). Studies performed with tomatoes produced in full sunlight vs. shade have shown that tomatoes produced in full sunlight contained more sugar and dry matter than those grown in shade (Winsor, 1979) (Table 1).

Temperature. The atmospheric environmental conditions, which include carbon dioxide concentration, relative humidity, and temperature, are often unmanageable in field production, but have strong implications for crop quality. For example, lettuce (*Lactuca sativa* L.) crops are typically produced in areas with cool days and nights to achieve firm but mild-flavored heads. If the crop is exposed to high temperatures or drought, bitter flavors can rapidly develop and the leaves become less tender (Peirce, 1987). Green beans (*Phaseolus vulgaris* L.) grown under controlled conditions at relatively low day

temperatures were more tolerant of ozone than beans grown at higher temperatures.

However, the opposite was true in studies performed with cucumber (*Cucumis sativus* L.) seedlings (Agrawal, 1993). Nilsson (1988) showed that the onset and rapid accumulation of sucrose in white winter cabbage (*Brassica oleracea* L., Capitula Group) was temperature-dependent and likely a consequence of a cessation of leaf production in the autumn.

Optimal temperatures for high ascorbic acid contents are usually lower (i.e., $<20^{\circ}\text{C}$), but exceptions do exist. The B-vitamins have also been observed to accumulate in higher concentrations at $10\text{--}15^{\circ}\text{C}$ in green vegetables, but in tomatoes accumulation was maximal at $27\text{--}30^{\circ}\text{C}$ (Shewfelt, 1990).

One of the most profound effects on the growth and development of produce quality is the initiation of the reproductive cycle in higher plants (Beverly et al., 1993). Flower initiation often depends on temperature. Differences between day and night temperatures have been shown to regulate stem elongation and flower stalk initiation (Agrawal et al., 1993). For example, in cole crops, the initiation of flowering or bolting is highly undesirable (Peirce, 1987). These cole crops will bolt with prolonged exposure to cool weather as days lengthen or nights shorten.

Water availability. Water availability and relative humidity also play a role in determining crop quality. An important example of this is the influence of low relative humidities on water potential gradients between vegetable tissues and dry air. As water is lost from the plant, water flows through the leaves, thereby limiting supplies of water and nutrients to fruits. Tibbitts (1979) has shown that low relative humidity can result in differential partitioning of calcium and boron in vegetables, resulting in nutritional disorders such as blossom-end rot of tomatoes and tip burn of lettuce. The extent of these disorders depends on the environment, water availability, and cultivar under investigation.

CO₂ enrichment. CO₂ enrichment of the atmosphere within greenhouses is a recommended practice in cooler climates like that of the northeastern United States and northern Europe (Hand, 1982; Kimball and Mitchell, 1981). There have been many studies conducted on the effect of CO₂ enrichment on photosynthesis and crop yield, but few studies have been reported on the effects on flavor quality. Kimball and Mitchell (1981) found that CO₂ enrichment had no significant effect on tomato acceptability in terms of appearance or crop quality. Enrichment with CO₂ at $1000\text{ }\mu\text{L}\cdot\text{L}^{-1}$ increased vitamin A content with lack of ventilation, but did not affect vitamin C content in fruit. Other studies have shown that ascorbic acid content of tomato fruits with CO₂ at $1000\text{ }\mu\text{L}\cdot\text{L}^{-1}$ was higher and increased with increasing CO₂ concentration (Madsen, 1975).

CULTURAL PRACTICES

Producers of vegetable crops attempt to optimize yields and crop quality through the use of selected cultural practices during the production season. A description of cultural practices in this context is a very broad area, by nature of the diverse practices that are used for the more than 50 crops that can be classified as commercial vegetables.

Table 1. Effects of shading on dry matter and sugar content of tomato fruit (Winsor, 1979).

Cultivar	Dry matter (%)		Sugars (g·100mL ⁻¹)	
	Shaded	Unshaded	Shaded	Unshaded
Potentate	5.7	6.4	3.0	3.8
Alisa Craig	5.6	7.0	2.7	3.7

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Nonetheless, key practices involving soil nutrient and water management, in particular, have been shown to greatly impact crop quality and postharvest storage life of many vegetable commodities. Although the effects of temperature extremes encountered in the field can be managed to some extent through the use of protective strategies, including irrigation and floating row covers, producers cannot greatly increase or decrease temperatures encountered in the field. Therefore, we will consider temperature an unmanageable environmental factor (Beverly et al., 1993) and instead focus on cultural practices involving soil nutrition, water, and pest management and their effects upon vegetable crop quality. Environmental conditions that have been identified as factors involved in the nutritional quality of vegetables include soil fertility, moisture content of the soil, use of growth regulators, and other cultural practices, such as plant spacing (Shewfelt, 1990).

Soil nitrogen. The literature suggests that much of the variation encountered in nutrient content in fruits and vegetables can be attributed to soil fertility. Nitrogen availability is closely linked to protein and carotenoid biosynthesis in higher plants. Nitrogen also influences the protein : carbohydrate ratios encountered (Mengel, 1979). Nitrogen deficiencies in the soil generally result in decreased protein in the harvested vegetable (Salunkhe and Desai, 1988). Adequate levels of soil nitrogen can result in improved quality of vegetables, generally by allowing for the development of sufficient photosynthetic surface area in higher plants. For example, Dufault (1988) has shown that nitrogen application improved head quality in broccoli (*Brassica oleracea* L., Botrytis Group). The application of nitrogen fertilization to fresh vegetables generally resulted in increased nitrate concentration in edible plant parts (Salunkhe et al., 1991).

Excessive soil nitrogen has been shown to result in reduced ascorbic acid content in vegetables (Salunkhe and Desai, 1988) and evidence suggests that increasing soil nitrogen may also create imbalances in the levels of essential amino acids in the harvested commodity at the expense of protein quality (Eppendorfer, 1978). Augustin (1975) found that ascorbic acid content of newly harvested potatoes (*Solanum tuberosum* L.) in response to nitrogen fertilization depended on the cultivar, but a general tendency was observed for decreased ascorbic acid content with increasing amounts of nitrogen fertilizer. Sorenson (1984) also found that decreases in ascorbic acid and dietary fiber of harvested cabbage were correlated with increases in nitrogen fertilization and higher head moisture content. Excessive nitrogen levels have been associated with storage disorders and poor quality of harvested produce. In broccoli, increased incidence of hollow stems followed high nitrogen application (Vigier and Cutcliffe, 1984). In sweetpotato [*Ipomoea batatas* (L.) Law.], increased weight loss during storage was closely related to nitrogen application (Hammett and Miller, 1982). Maynard (1984) found that heavy N fertilization caused accumulation of potentially hazardous concentrations of nitrate nitrogen, which adversely affected nutritional quality of many vegetables. This is especially true in leafy green vegetables, such as spinach (*Spinacia oleracea* L.). When light intensity is limiting, nitrate nitrogen concentration in leaf tissue is generally highest (Blom-Zandstra, 1989). Interestingly, Van Wassenhove et al. (1990) found that the addition of high levels of nitrogen fertilizers to celery (*Apium graveolens* L.) resulted in decreased amounts of celery volatiles that impact the characteristic flavor of celery. The reason for this biosynthetic response to nitrogen is unclear, but an effect of nitrogen on carbon flow was evident.

Other soil nutrients. High rates of fertilizer phosphorus produced a higher sugar content in tomatoes, as measured by soluble solids concentration, than did low rates. In addition, phosphorus deficiency led to poor quality and fill of corn (*Zea mays* L.) ears as compared to higher levels (Salunkhe and Desai, 1988). Potassium can also have significant impact upon crop quality; optimal levels of potassium elicit a favorable response in vitamin C content. According to Winsor (1979), increasing levels of total and titratable acidity were obtained in tomatoes with increasing concentrations of potassium. Bres and Weston (1992), in hydroponic experiments, found that potassium concentration and pH had limited effects on tipburn in several lettuce cultivars. Tipburn did appear to be related to cultivar type and environmental conditions maintained during greenhouse growth. In-

creasing the pH of the nutrient solution did result in increased proportions of potassium, compared to magnesium or calcium, in harvested lettuce. Calcium and magnesium levels in the soil also can have an important effect upon the soil pH and the availability of other nutrients (Salunkhe and Desai, 1988). It has been shown that calcium content of vegetables grown in limed soil influences the pectic components of the cell wall. Winsor (1979) reported that calcium was used to enhance the firmness of processed tomatoes for canning. In addition, many studies have shown that calcium deficiency causes many important physiological disorders affecting the quality of many vegetable crops, including tipburn in leafy crops, blossom-end rot in solanaceous species, and blackheart in celery (Beverly et al., 1993). Other disorders of vegetable crops are also related to deficiencies or toxicities of micronutrients that affect postharvest and nutritional quality of the produce (Salunkhe and Desai, 1983). Deficiencies or toxicities of boron, copper, and molybdenum, in particular, are associated with specific vegetable disorders.

Water availability. Water availability is an important factor influencing vegetable nutrition and quality. Drought stress or flooding can result in plant death and photosynthetic reductions (Janoudi et al., 1993). Moisture deficits in the soil have been shown to influence ascorbic acid contents in vegetables. For example, snap beans and tomatoes exhibited responses to irrigation and or drought stress as measured by ascorbic acid content. Tomato, pepper (*Capsicum annuum* L.), and other vegetables have shown increased vitamin C levels in the presence of drip irrigation (Cevik, 1981). Increasing the water availability through the drip line resulted in increased tomato fruit color, size, and acidity but decreased total soluble solids concentration (Sanders et al., 1989). Other reports examining drought stress or salinity effects on tomatoes have shown that total soluble solids concentration, sugar, acidity, and flavor all increased with increasing stress (Beverly et al., 1993). Improved quality in tomato fruit may result in an increase in carbohydrate storage in leaves and stems in drought-stressed fruit (DeKoning and Hurd, 1983). The improved fruit quality observed with a moderate level of stress may, however, be accompanied by reductions in tomato yield. Internal white tissue and decreased decay was most common in irrigated plots and in wetter growing conditions than in non-irrigated plots (Brecht et al., 1994). In a recent study performed by Johnson et al. (1989), spinach cultivars were produced under normal and high rainfall conditions and then evaluated for shelf life and postharvest quality. High rainfall during the growing season reduced spinach storage potential by an average of 40%. Plant type (savoy vs. common) and temperature did not have an effect on postharvest storage potential.

Growth regulators and pesticides. The use of synthetic compounds for pest control or growth regulation in higher plants can have very significant effects upon vegetable yields and postharvest quality. Typically, vegetable crops are high-value commodities that are produced with high inputs of water, fertilizer, pesticides, and growth regulators, if need be. The use of pesticides and growth regulators can positively or negatively affect vegetable appearance and nutritional value. In studies performed with storage onions (*Allium cepa* L.), preharvest treatment with maleic hydrazide, a sprout inhibitor, resulted in reduced incidence of bulb decay over 3 months and root sprouting, whereas preharvest rolling of bulb tops to improve drying resulted in increased bulb decay (Toledo et al., 1984; Table 2). Treatment of potatoes with sprout inhibitor CIPC resulted in significantly increased total nitrogen and protein nitrogen following 16 weeks of storage at 5 °C (Seetharam and Mondy, 1991). The level of gibberellins and abscisic acid in attached leaves of aging lettuce was evaluated over time as it senesced. Senescence in romaine lettuce leaves was found to be associated with a depletion or reduction of free gibberellins and cytokinins, which are also impacted by environmental conditions preceding harvest (Aharoni and Richmond, 1978). Afek et al. (1995) found that treatment of celery with gibberellins before storage resulted in reduced celery decay by reducing the conversion of (+) marmesin to psoralens, thereby increasing resistance to pathogens in storage (Figure 1). Broccoli plants and heads were treated with benzyladenine (BA), a treatment that has not yet been approved for commercial use as either a preharvest spray or a postharvest dip, and quality was evaluated over time. Preharvest treatment with BA gener-

ally resulted in best color retention in broccoli that was stored on ice or packaged (Shewfelt et al., 1983). In many cases, the use of growth regulators can increase crop postharvest quality by slowing senescence.

Pesticides can impact crop quality positively or negatively. The use of plant protectants for control of pests, including weeds, insects, and diseases, is widely associated with often dramatic increases in crop quality as the pest is controlled. However, efficacious control of the pest by chemical application may also result in secondary effects upon vegetable crop quality. For example, the application of metribuzin [(4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one)] herbicide to the soil before potato emergence resulted in tubers of higher nitrogen and protein and lower nitrate levels (Mondy and Munshi, 1990). Metribuzin is a potent inhibitor of photosynthesis in higher plants. Whether this difference is due to improved weed control and crop growth or a secondary chemical effect upon nitrogen content is unknown. In recent studies performed by Barth et al. (1995), the use of clomazone [2-(2-chlorophenyl) methyl-4, 4-dimethyl-3-isoxazolidinone] herbicide, an inhibitor of carotenoid biosynthesis in higher plants, and ethalfluralin [N-ethyl-N-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl) benzenamine] herbicide (the industry standard for treatment of squash) were evaluated on six cultivars of processing squash (*Cucurbita* sp.) and pumpkin (*Cucurbita* sp.). The use of soil-applied clomazone for preemergence weed control was associated with paler color in harvested fruit in several sensitive cultivars, including 'Golden Delicious' (Table 3). Other cultivars were unaffected by clomazone application. Further analysis of fatty acids, ascorbic acid, and soluble solids concentration of extracted fruit showed no effect of clomazone on these compounds. Herbicide treatment did influence peroxidase activity in 'Turks Turban' and 'Buttercup' squash (Table 4). In contrast, a study in Belgium recently showed that a wide range of fungicides, insecticides, and growth regulators had virtually no influence on the composition of tomato fruit. This result was deemed important, as these chemicals are used extensively throughout Europe in greenhouse vegetable production. The use of the soil sterilant methyl bromide, however, reduced the ascorbic acid content of tomatoes by about 15% (Gormley, 1989).

Fruit maturity. Optimal fruit maturity is determined by the type of vegetable crop produced and its use for consumption. For example, the stage of maturity considered optimal for canned produce may not be desirable for fresh or frozen use (Salunkhe et al., 1991). Because vegetable quality and size can vary between individuals in a population and fruits on a plant, the timing of harvest can have a great impact on the quality of produce available (Beverly et al., 1993). Multiple harvests are often useful in increasing the proportion of the crop at optimal maturity.

The maturity at harvest can also significantly impact nutritive value of the crop. For example, small cabbage heads are higher in ascorbic acid concentration than large heads. Small turnip (*Brassica rapa* L.) leaves contained more thiamin and riboflavin but less carotene than large leaves (Salunkhe et al., 1991). Most cole crops showed maximal nutritive value at harvest time and not after storage. In snap beans and other green vegetables, ascorbic acid tends to increase with maturation and decrease with advanced maturation. Carotenoids tend to increase during ripening of fruit, such as tomatoes. However, Watada et al. (1976) found that ascorbic acid and β -carotene contents were similar in vine-ripened vs. mature-green tomatoes for several cultivars. In sweetpotatoes, protein content generally declined with increasing maturity time prior to harvest (Shewfelt, 1990). The relationship of nutrient content to fruit maturity was dependent largely on vegetable type and cultivar.

Generally, fruits that have a shorter production season and mature earlier have a shorter storage life than slower-maturing fruit (Salunkhe et al., 1991). The physiological basis for the influence of fruit maturity on postharvest quality and storage life is often not understood, but is receiving some attention in the literature. Sharrock and Parkes (1990) monitored various characteristics during growth and storage of buttercup squash in an attempt to identify the physiological basis for the influence of fruit maturity on their susceptibility to rot in storage. Fruit harvested late and less resistant to pathogen attack consistently exhibited higher levels of titratable acids, tissue water potential, total soluble

solids, and exochitinase activity. The authors believe that changes in any one characteristic are unlikely to be responsible for improved storability of early fruit. Hawthorne (1990), also in studies with cucurbits ('Crown', 'Triamble', 'Butternut', 'Supermarket') found that older fruit that remained attached to the vine before harvesting was more susceptible to storage rots than those that were unattached. Studies conducted with spaghetti squash showed that storage of half-mature fruit increased spaghetti quality over time. Half-mature fruit were able to be stored over 1 to 2 months (Edelstein, 1989). In studies conducted with greenhouse-grown peppers, fruit were harvested when mature-green or fully ripe (red or yellow >95%). Ripe peppers were less susceptible to chilling injury when held at 1 °C for 1 to 2 weeks, whereas mature-green fruit showed injury. It appeared that ripe peppers could be stored at lower temperatures than those typically recommended (Lin et al., 1993). Much work remains to be done to determine the physiological basis for effects of fruit maturity on crop quality and storability.

Table 2. Effect of preharvest application of maleic acid or rolling bulb tops on decay of onion bulbs during 3 months of storage at 1 °C (Toledo et al., 1984).

Treatment	Decay (%)
Maleic Hydrazide	
+	36
-	30
Rolling tops	
+	52
-	28

Fig. 1. The incidence of decay in GA³-treated celery during 4 weeks of storage at 2 °C (Afek et al., 1995).

Table 3. Influence of clomazone and ethalfluralin herbicide (active ingredient, a.i.) on total carotenoid content in 'Golden Delicious' squash at harvest (Barth et al., 1995).

Herbicide treatment	Rate (a.i., kg·ha ⁻¹)	Total carotenoids (ug·g ⁻¹)
Ethalfluralin	0.8	2.46
Clomazone	0.6	1.68
Clomazone + Ethalfluralin	0.3 + 0.8	2.78
Clomazone + Ethalfluralin	0.6 + 0.8	2.66

Table 4. Influence of clomazone and ethalfluralin herbicide on peroxidase activity (fresh weight basis) in 'Turk's Turban' squash after 4 weeks of curing (Barth et al., 1995).

Treatment	Rate (a.i., kg·ha ⁻¹)	Peroxidase activity (mmol·s ⁻¹ ·g ⁻¹)
Ethalfluralin	0.8	1.01
Clomazone	0.6	8.69
Clomazone + Ethalfluralin	0.3 + 0.8	1.39
Clomazone + Ethalfluralin	0.6 + 0.8	1.12

GENETICS AND CULTIVAR SELECTION

In addition to the preharvest conditions discussed above, genetics and cultivar selection are major factors involved in postharvest quality outcomes for vegetables (Adamicki et al., 1989; Bittenbender and Kelly, 1988; Johnson et al., 1989; Takahata et al., 1993; Watada et al., 1976). Since cultivars vary in genetic makeups, they will vary in attributes such as size, color, flavor, texture, nutrition, pest resistance, processing ability, eating quality, and yield (Beverly et al., 1993). Since vegetables are important sources of essential antioxidant vitamins in the human diet, it is important to assess new cultivars for nutritional quality.

Influence of cultivar. New cultivars are often developed for improved disease resistance, environmental adaptability, and quantity of high quality harvested fruit and vegetable products; however, nutritional quality also can vary greatly. In potatoes, 'Granola' and 'Russet Norkotah' had higher antioxidant activity than 'Yukon Gold' and 'Viking' (antioxidant index = 88–89 vs. 65–68). Lee et al. (1995) determined levels of ascorbic acid in several pepper types. Levels of L-ascorbic acid amount in pepper types varied considerably (Table 5). Levels also varied within specific pepper types. For example, in jalapeno peppers, highest ascorbic acid levels were in 'Jaloro' (131 mg·100 g⁻¹) and the lowest in 'Mitla' (49 mg·100g⁻¹). Takahata et al. (1993) reported wide variation in β -carotene content of several cultivars of sweetpotato (Table 6). Amino acid composition of the sweetpotato flour of each cultivar was similar. The genotypes exhibiting relatively high fructose and glucose contents ('Murasakibaru', 'Tokai 5', 'Georgia Jet') were suggested as appropriate for the processing of sweetpotato for frozen or chilled products. 'Georgia Jet', suggested for processing, contained low concentrations of β -carotene (6.9 mg·100 g⁻¹). There is a need to identify and/or develop cultivars suitable for processing and high in antioxidant vitamin quality.

Use of traditional and molecular techniques. Traditional plant breeding based on selection of desirable genotypes and development of inbred lines offers potential to reduce susceptibility to environmentally-induced decay, leading to improved postharvest quality (Beverly et al., 1993). Nagata et al. (1992) reported that 'Florida Buttercrisp' lettuce, a cross between 'Montello' and 'Brazil-48', is resistant to corky root and premature bolting and is tolerant to tipburn and lettuce mosaic virus. Leaves were more durable, resulting in reduced damage during postharvest handling, and palatability was considered excellent.

Diawara et al. (1993) evaluated new celery genotypes with resistance to major celery disease, thought to be due in part to furanocoumarin production, for potential components of an integrated pest management program. Because higher levels of furanocoumarin in celery are also correlated with higher incidence of skin disorders in humans (Grekin and Epstein, 1981), it is important to evaluate these com-

pounds in new genotypes. Levels of furanocoumarins were found to vary due to environmental conditions.

Genetic engineering techniques are also important in improving vegetable postharvest quality (Bartels, 1989; Grierson, 1991; Smith, 1990). Smith (1990) showed that polygalacturonase antisense gene (PG) reduced the level of PG enzyme to 1% of normal, resulting in a tomato with potentially extended shelf life. No changes in lycopene or ethylene synthesis were observed. Adamicki et al. (1989) reported storage life and quality of F₁ hybrid tomatoes with the nonripening gene to be similar to those of a standard cultivar. They found small differences in ascorbic acid levels and no difference in total sugar levels in vine-ripe fruit. However, during storage, the percentage of ripened fruit was higher in the standard cultivar than the tomato fruit with the *nor* gene. Improvements in virus and herbicide resistance and product quality have been reported in transgenic tomato plants and legumes; however, most of the quality characteristics are under multiple gene control in which the genetics are not as well understood (Beverly et al., 1993; Smith, 1990).

Genetic engineering has been demonstrated to be successful in altering certain vegetables for quality and yield; however, the commercial application of genetic engineering of plants will depend largely on consumer acceptance and food safety issues.

Preharvest factors can have profound influences on the postharvest quality and nutritive value of vegetables. Future research on those factors under human control, including field management practices and cultivar selection and improvement, offer potential for enhancement of postharvest vegetable quality. In particular, improved management of soil fertility and water offer much promise. Further research relating to the development and management of superior cultivars is needed, particularly with regard to nutritive quality of many vegetables.

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Table 5. Influence of cultivar on L-ascorbic acid content of fresh pepper cultivars (Lee et al., 1995)

Cultivar	L-ascorbic acid mg·100g ⁻¹
Veracruz (Jalapeno)	72
Gold Spike (Wax)	115
Green Chile (Chile)	122
San Luis Ancho (Ancho)	168
Hidalgo (Serrano)	64

Table 6. Influence of cultivar on β -carotene content (fresh weight basis) of sweetpotato cultivars (Takahata et al., 1993).

Cultivar	β -Carotene content (mg·100g ⁻¹)
SPV-61	26.6
Resisto	20.3
Santo Amara	15.5
Heart Gold	9.9
F411	7.8
Georgia Jet	6.9
SPV-43	1.1

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