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STRATEGIES TO ENHANCE POST-HARVEST QUALITY AND SHELF LIFE OF PEACHES

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Abstract: The aim of this review paper is to gather the available important information to know how the strategy of prolonging the shelf/storage life of peach by controlling various factors affecting its life. It contains the research works performed in the last decades concerning the various factors like disease management, chilling injury, internal breakdown and browning for increasing the shelf life of peaches. Although many studies have demonstrated the efficacy of alternative postharvest treatments but only a few of them are commercially applied, others although demonstrated but not adapted so far due to the limitations of cost, delays in registration processes or their efficacy. Therefore, these areas should be dealt to resolve the obstacles to make all these strategies available and adaptive in near future so that the shelf life and quality of peaches can be improved and its import can fetch good reputation and earn more income.

Keywords: Chilling Injury, Internal Breakdown, Browning and Diseases.

Introduction

Peach is known as *Prunus persica* (L.) belongs to the family *Rosaceae*. Years back it was also known as 'Persian apple'. It has been originated from China, spread to Persia, Europe then to California, which is considered as the important production area after China and Italy (LaRue, 1989). In Pakistan, peach is an emerging fruit crop cultivated over an area of 13.8 thousand ha with 70 thousand tons production. Major contribution is from Khyber Pukhtunkhawa where it covers 7,984 ha with annual production of 52,005 tons (GOP, 2016). The annual world production of peach and nectarine is about 20.27 million tons with an area of 1.53 million ha (FAOSTAT, 2011). Recently an important development is made in the peach fruit characteristics, having high aromatic white flesh, more soluble solid content (SSC), and low acidity in white and yellow cultivars (Crisosto and Mitchell, 2002).

Peach is a soft-flesh fruit and highly perishable with limited market life. It contains 87% water and 43 kcal energy, organic acids, vitamins, carbohydrates, pigments, volatiles, phenolics, antioxidants and traces of lipids and proteins (USDA, 2003). Immature fruits contain starch which converts to soluble sugars when fruit matures. Hence, no significant increase in soluble sugars has been observed during ripening and storage (Romani and Jennings, 1971). Of the total soluble sugars 75% consists of sucrose, fructose and glucose. Malic acid, the organic acid is present in the mature fruits; decreasing by 30% acidity has been reported during ripening. Protein content (0.5 to 0.8 % fresh weights) in peach serves as a catalyst in various chemical reactions during compositional changes. While lipid (0.1 to 0.2 % FW) serves as surface wax and improves its appearance and protects from pathogens and water loss. Minerals consist of acid (P, Cl, S) and base (Ca, Mg, K, Na) forming elements. Ca in cell wall is associated with fruit softening while Ca in apoplast is associated in senescence (Crisosto and Valero, 2008). Volatile compounds like alcohol, esters, ketones, aldehydes and acids present in small amounts are responsible for aroma. Carotenoids (pro vitamin A), phenolic compounds and ascorbic acid (Vitamin C) present in peach are good antioxidant source (Tomas *et al*., 2001). As they are mostly restricted to the surface, it has been recommended to eat the peel to ensure maximum intake of antioxidants (Gil *et al*., 2002). Now fresh cut slices of peach fruit are also in business due to its short market life (Gorny *et al*., 1999). Culled peaches are a good source of energy and are palatable but for its low protein contents they can be used mainly for cattle feed. Its water content is 85% due to which dry area animals will not need extra water. Fuel alcohol can be produced by culls but it is limited because of low sugar i.e., 8-12 %. In California, culls can be frozen, canned, or used for making juices or other value added products. When the fruit decays or infected by worms it can be used as green waste for compost over ripe or under sized fruit can be dried and used for human consumption (Thompson, 2002).

Peaches have short shelf life as they belong to the category of climacteric fruits. Postharvest decay is the major limiting factor in extension of storage life of peaches (M. Alizade-Dashqapu *et al*., 2011). Grey and blue mold caused by *Botrytis cinerea Pers* and *Penicillium expansum* Link, respectively, are the major casual agents of postharvest diseases of peaches (Lurie *et al.*, 1995).

Mainly the post harvest losses occur as a result for internal breakdown or chilling injury and fruit decay (Mitchell and Kader, 1989 a). Stone fruit decay is mostly due to fungi *Botryis cinerea* which causes Botrytis rot. Although induction of disease resistance using antagonistic yeast or MeJA separately is well documented, there is little information about the effect when used in combination. *Monilinia fructicola* is a main postharvest disease of peach fruit, and *Penicillium expansum* is also an important pathogen causing serious decay in stone fruit during postharvest storage in China (Tian *et al.*, 2004). Respiration in fruits is responsible for its deterioration (Kader *et al.,* 1989).

Peach fruit usually have a very short postharvest life. Decay is an important factor, which limits the storage life of peach, and results in appreciable losses at wholesale, retail, and consumer levels. Control of postharvest diseases of fruit is mostly dependent on controlled atmosphere storage, refrigeration and fungicides (Kader and Mitchell, 1989). Internal breakdown or chilling injury is affected by storage temperature. It causes hard texture or non juicy fruit, browning of flesh or pit cavity. In susceptible cultivars fruit loses its flavor before showing chilling injury symptoms. Internal breakdown varies between cultivars. Early cultivars are less susceptible to chilling injury than the mid or late season cultivars (Mitchell & Kader, 1989 a), but in the new cultivars susceptibility to chilling injury is random (Crisosto and Michell, 2002). The susceptible fruits show the symptoms of chilling injury fast when stored at killing zone temperatures i.e., 2.2 °C and 7.6 °C as compared to 0 °C storage or below but above the freezing temperature (Mitchell and Kader, 1989 a). So the market life reduces when exposed to Killing Zone, temperature, severity of chilling injury depends on the ripening stage at the time of harvest like May crest, cv. showed more injury when harvested at more ripened state, but cultivars harvested at early ripening stage showed opposite behavior (Valtero *et al.*, 1997; Crisosto *et al*., 1999 c).

This disorder can be delayed or avoided by applying some treatments like application of Calcium, warming cold storage interruptions, Controlled atmosphere (CA) (Garner *et al.*, 2001). Controlled delayed cooling, plant growth regulators and CA during shipment and storage resulted in retention of ground color and fruit firmness. CA with 0 °C and 17 % CO_2 + 6 % O_2, resulted in decrease of internal breakdown during shipment in white flesh cultivar. Efficiency of controlled atmosphere is due to pre-harvest factors, cultivar, shipment time and marketing period, temper and fruit size (Mitchell and Kader, 1989 a; Crisosto *et al.*, 1999 a; Crisosto *et al.*, 1999 c). Another technique of (MAP) Modified Atmosphere packing has also decreased the chilling injury in peaches when the poly propylene standard film (12% CO_2 + 4% O_2) for oriented polypropylene (2% O_2 + 23% CO_2)was used which also reduced the incidence of chilling injury (Fernandez and Artes, 1998). Before storage or shipment pre conditioning treatment delay the internal breakdown symptoms (Crisosto *et al.*, 2004). "Paraguayo" cv. reduces chilling injury symptoms when subjected to warm cycles for 1 day at 20 ◦C every 76 days of storage at 2 °C (Ferrandez and Artes, 1998). Modified atmospheric packaging (MAP) storage can be applied successfully to prolong the storage life of peaches as it slows down the rate of respiration and retards the decrease in Titratable acidity, maintain sugar and soluble sugar content, vitamin C juice content, flesh firmness and slows deterioration through decreased fruit browning and injury (Bal, 2016). Fruit firmness should be 1.4 – 2.7 kg for its optimal ripeness, when kept at 5 °C storage temperature and RH 90-95 % for 2-8 days, maintains its quality. Shelf life can be increased by dipping the slices in calcium lactate and ascorbic acid or by using MAP (Modified atmospheric packaging). Now-a-days firmness can also be induced by giving the pre heat treatment for 70 minutes at under passing MAP condition 40 % before processing and packing which preserves its nutritive quality i.e., vitamins & organic acids (Steiner *et al*., 2006).

Most of the quality loss occurs due to mismanagement during harvesting and transport of the fruit. It includes impact abrasion compression and wounds or cuts, bruising to which peaches are susceptible (Mitchell and Kader, 1989a). Impact bruising is due to bouncing or jarring, dropping. When the fruit bins are stacked and over filled, fruits were crushed; which is called compression bruising. When the fruits are rubbed with the surface of container or with each other it results into abrasion bruising. These injuries can be reduced by proper handling and transportation which will also result in high quality fruit production. Careful handling is required in high quality fruit production. Careful handling is required during harvesting, hauling and packing to reduce injuries which may cause accelerated physiological activities, appearance, quality reduction, causing more entry points for decay causing organisms and more loss of water. To maximize fruit flavor peach industry harvest fruit more mature, the impact and compression bruising is now more concerned. During packaging operations and hauling to packaging house more impact bruising is reported. For nectarine and peaches critical impact bruising thresholds are being developed. During harvesting or from harvest till consumption physical cuts or wounds may occur (Crisosto *et al*., 2001b).

Sufficient protection is assured by supervision of good worker. At any time of post harvest handling abrasion damage can occur. During transportation reduced vibrations and immobilized fruit handling can reduce the abrasion damage. Before the fruit is transported to market many procedures to reduce abrasion damage should be adopted like transportation inside the field bins use of plastic film liners, avoiding abrasion on plastic lines. Installation of air suspension systems, special bin top pods installation before transport and in shipping container. Special immobilize packaging procedures should be adopted. Avoiding rough roads and following the track and speed limits is also important to reduce abrasion. Fruit susceptibility to mechanical damage can be reduced by treating peaches with growth regulators like gibberellic acid and polyamines before handling and storage operations, which will enhance the fruit firmness and compression forces resistance (Martinez *et al*., 2000). Another method to increase the resistance of fruit is also reported, i.e. pre-harvest spray (Ca + Mg+ Ti) application will produce firm fruit (Serrano *et al*., 2004).

When the fruits having heavy metal contaminants like Cu, Fe and Al are damaged by abrasion during harvest, skin discoloration or dark discoloration known as inking occurs (Cheng and Crisosto, 1997). This cosmetic problem will cause market rejection and grower loss. After 24-48 hours of harvest fruit shows these symptoms. This contamination is due to spray of fungicides or foliar nutrients within 7 – 15 days before harvesting. Thus to avoid this problem within 15 days any fungicide or foliar nutrients should not be applied and pre harvest guide lines of fungicides sprays should be followed (Crisosto *et al*., 1999b).

Pre and post harvest factors are responsible for post harvest quality of peach, as it is climacteric and highly perishable, deterioration process is rapid. These cause high economic loss as compared to pre-harvest losses (Salunkhe *et al.,* 1991). Surface treatments keep the fruit quality intact. Salicylic acid is present in plants hormones group (Raskin, 1992), it is present in plants territory (Raskin *et al.*, 1990). It is reported that salicylic acid is responsible for metabolism in plants (Popova *et al.*, 1997). It improves the quality of many crops, as it is endogenous growth regulator and belongs to phenolic group (Peng and Jiang, 2006). It also plays role in physiological or biochemical processes such as enzyme activity, ion uptake, heat production, membrane permeability and growth and development of plant (Arberg, 1981). In peaches salicylic acid reduces quality loss. Salicylic acid controls fruit firmness and increases fruit life. It also increases flesh firmness of peaches during storage (Wang *et al.,* 2006).

Four concentrations (0.5, 1, 1.5 or 2 mmol L^{-1}) of salicylic acid were used to check the effect on storage life. Fruit with 2 mmol L^{-1} showed high flesh firmness, low weight loss, high Titratable acidity and SSC as compared to other treatment concentrations and control. Thus, we could conclude that for commercial preservation up to 5 weeks 2 mmol L^{-1} should be used (Salunkhe *et al.,* 1991). Peach fruit was dipped in Salicylic acid (0, 0.5, 1, 2 mM) and stored at RH 95 % at 1±1 ^{o}C for 6 weeks. Fruits treated with 1 mM salicylic acid showed less weight loss and chilling injury as compared to other treatments. It maintains membrane integrity and delays ripening of fruit and improves quality of peach fruit (Awad, 2013).

By the application of salicylic acid at 0, 1.5, 3 mM for 15 minutes at 5 ^{o}C up to 60 days, it was found that vitamin C is influenced by salicylic acid application and decreases weight loss and prevents softening of fruits (Kazemi *et al*., 2011). Thus cold storage reduced respiration, production of ethylene and extends shelf life (Fattahi *et al.*, 2010).

Calcium is one of the important elements affecting the post harvest life and quality. Its deficiency causes many diseases i.e., cork spot, bitter pit, senescent breakdown and water core. It deficiency also causes early fruit drop and cannot be stored longer. Lower amount causes cell wall softening during post harvest storage. It has well defined roles in tissue firmness preservation, senescence retardation, fruit ripening, reduced ethylene production, CO_2 and lowering the respiration rate, prevention of flesh browning, internal breakdown and mold decay (Alizade-Dashqapu *et al*., 2011). Calcium is important in cell function and integrity of plant tissues (Elad and Krishner, 1992). Its physiological activity and requirement in cell wall structure is responsible for fruit growth and development and fruit quality, fruit senescence, resistance to disease and other stresses (Kazuhiro *et al.,* 2004; Elmer *et al.*, 2006).

Foliar spray with Ca^{+2}, Mg^{+2}, Ti^{+4} was applied on nectarine and peach trees. At harvest stage both treated cultivars showed high weight and pulp firmness compared to control, but did not affect color, TSS and TA. During storage of treated fruits low weight loss, color evolution ethylene production and TSS/TA ratio and high pulp firmness was observed and storage also extended up to 14 days as compared to control. During ripening at 20 °C ripening parameters were slow in treated and delayed ethylene production than that with control (Alcaraz-Lopez *et al*., 2004).

Pre and post harvest applications of $CaCl_2$ (2000 ppm), Nutrical (8 % soluble Ca solution) 2000 ppm was used to check shelf life and quality of peaches. Fruits were stored for 7 weeks at 3 °C. Results showed that calcium application has enhanced the firmness of fruit and ripening was delayed. Calcium plays its role to maintain fruit textural strength (Poovaiah, 1986). 60 % fractions of cell wall are associated with calcium (Rossignol *et al.,* 1977). Middle lamella of cell wall is made up of pectin which forms Ca-pectate when interacts with Ca^{+2} and cohesiveness of cell to cell increases (Dey and Brimson, 1984). Calcium also reduces the production of ethylene, poly-galacturonase and cellulase activities (Conway, 1987). Calcium application at pre and post harvest stages reduces senescence (Lester and Grusak, 2000).

On peach cv. 'Earli Grande' calcium chloride treatments for 4 % and 6 % for ten minutes were investigated and were packed in corrugated fiber board boxes and wooden boxes, after air-drying kept in cold storage at 0-2 °C and RH 85-98 %. It was found that fruits dipped in $CaCl_2$ 6 % for ten minutes and packed in corrugated fiber board boxes, (2 kg) stored for 21 days were having reduced spoilage and pectin methyl esterase activity and maintains palatability and acidity, thus having good market quality (Gupta *et al*., 2011).

Application of calcium nitrate, calcium chloride or a calcium amino acid chelate (Metaloste calcium) improved peel growth cracking, fruit firmness and reduces fruit rots after harvesting. Fruit size also increased by calcium amino acid chelate (Taylor and Brannen, 2008).

At the end of this review we concluded that disease management, chilling injury, browning etc are affecting the shelf life of peaches which can be controlled by the effectiveness of alternative postharvest treatments but only a few of them are commercially applied, others although demonstrated but not adapted due to the limitations of cost, delays in registration processes or their efficacy. Therefore, these areas need special attention in developing all these strategies available and adaptive in future. In this way, the shelf life and quality of peaches can be improved and its import can fetch more revenue to the country adding to GDP growth.

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