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Post-harvest health maintenance of grapes -a review

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Abstract

Grape is a highly perishable fruit and can not be stored for longer time under ambient conditions. Many workers had tried to increase its shelf-life by pre-cooling, fumigation, pre and post-harvest chemical treatments, packaging, controlled atmosphere and cold storage which are reviewed in this paper.

Key words: *Grape, storage, quality, pre-cooling, fumigation, chemicals, packaging and controlled atmosphere*

Introduction

Grape is a delicious, refreshing and nourishing fruit. Although it is a temperate fruit of India but can also be grown successfully in southern and coastal areas of India. Area under grape cultivation has increased which leads to the glut of grapes in the market and hence lower return to the growers. Grape is a highly perishable fruit and can not be stored for a longer time at room temperature. There are heavy post harvest losses in grapes mainly due to loss in weight and decay. Many attempts have been made by various research workers to increase the shelf-life and maintain the quality of grapes which are reviewed in this paper. Factors affecting the post-harvest life of grapes are discussed below :

Climate and culture practices

Prevailing environmental conditions at the time of ripening and harvesting plays the major role in determining storage life of the fruits. Similarly cultural practices such as soil type, quality of available water, variety, time of irrigation, fertilization, harvesting and handling have a great influence on keeping quality of grapes. Rains during the ripening season and at harvesting time increased the post-harvest losses (Beattie and Outhred, 1970). Reich (1979) reported that different irrigation regimes altered the rate of fruit ripening thus affected the keeping quality of grapes. The berry cracking during storage was more in thin skinned varieties like Thompson seedless and Tokay (Ryall and Harvey 1959). Chadha and Randhawa (1974) reported that Anab-e-Shahi and Angur Kalan grapes have poor keeping quality due to their weak pedicel. Nelson (1951) observed that varietal difference for botrytis infection and susceptibility to various rots. Thompson seedless which has maximum storage life of 3 months respire more rapidly and evolve more vital heat from Emperor and Almeria cultivars at 0°C (Winkler, *et al.*, 1974). The shelf-life of the berries grown in the desert region was far superior to those grown on the clay soil, due to negligible losses in weight, juice or decay after one week at room temperature. Berries grown in the desert region had lower rates of berry shatter than on clay soil. Fungal decay was greatest in berries from the clay soil (Hegazi and Barkoki, 1994).

Pre-cooling

Pre-cooling means rapid cooling after harvest. Pre-cooling of the produce soon after harvesting helps in maintaining of the produce quality and is an essential component of cold chain. Pre-cooling of produce reduces field heat, rate of respiration, rate of ripening, loss of moisture, production of ethylene and spread of decay. Various methods of pre-cooling used for fruits and vegetables includes room cooling, forced air cooling, hydro cooling and evaporative cooling . Pre-cooling removed the field heat of commodity and increased the storage life (Maini, 1985). Pre-cooling of fruits with in 48 h after harvesting is essential for long storage life (Dewey, 1950). Nelson (1955) reported that a reduction in temperature to 9.5°C halved the rate of respiration and doubled the shelf life of grapes. It also checked stem desiccation, browning, berry shattering and softening. Precooling of perlette grapes maintained berry firmness (Ber - Arie, *et al.*, 1984). Vaccum precooling was the most rapid and beneficial method for table grapes (Andre, *et al.*, 1977). Lowest quality deterioration in cultivars Coarna Neagra and Muscat of Hamburg was observed with Packing after 4 h of harvest and stored at 2-4°C for 120 days (Popa and Fugel, 1982). Minimum physiological loss in weight and decay loss were recorded in the fruits dipped for 5 min. in cold at water and 5°C followed by 10 min dipping at 5°C (Nain, *et al.* 1996). Forced air cooling reduced temperature from 27°C to -0.5° with in 6 hrs (Ginsburg, *et al.*, 1977). The optimum wind speed for cooling for 2-3 hrs was 4 m/s (Mongelli, 1982). Rapid cooling caused the moisture loss. The grape consignments for air shipment need to be cooled below 10°C, for rail road and sea shipment to below 4-5°C and for cold storage to -0.5 to 0°c (Arve, 1985).

Fumigation

Fumigation is an important step of post-harvesting handling chain of grapes. Storage and transit rots can be reduced by fumigation. SO_2 treatment reduced the activity of decay causing organisms and retained the natural condition of berries and stem structures during handling of grapes (Lutz, 1938; Harvey, 1956). It also influenced the physiological processes of table grapes. Respiration rate (Pentzer, *et al.*, 1933) and ethylene production (Singh and weaver 1982) were remarkably reduced in sulphur dioxide treated fruits. Spread of *Botrytis* on grapes in storage can be inhibited by SO_2 fumigation exposure of 5-10 minutes (Malan, 1955). Fumigation is usually done before the grapes are precooled because the warm fruit assess more gas than cold fruit (Roy, 1985). Pentzer and Barger (1941) used a large number of fungicides in various forms and found that fumigation with 1%, SO_2 for 20 min was most effective. King (1986) obtained the control of storage rots in wrapped and unwrapped grapes by weakly fumigation with 0.1% SO_2 in the cold storage. Higher concentrations (0.5% and 1.0%) of SO_2 caused injury and fruit.

Stem drying, browning and berry rot can be reduced by use of 'Quick Release' grape guard (Mansour *et al* 1984). Storage life of Thompson seedless and Anab-e Shahi increased upto 80 and 70 days by use of 'Dual Release' sulphur dioxide generators in vented polyliner under cool condition. Perlette grapes can be successfully stored for upto 40 days by enclosing quarter size, 'Dual Release' SO_2 generators in polyliners having 1.12% perforation in cold storage (Sandhu, *et al.*, 1990). With 'Dual Release' SO_2 generators Beauty Seedless Grapes could be stored upto 80 days in refrigerated conditions (Ladania and Dhillon, 1987). Quality of Thompson seedless was maintained during cold storage of 105 days by using just one bag/pack of SO_2 generation (UVAS) for 6, 8 or 10 kg packs wrapped in perforated polyethylene bags (PPE) (Soylemezoglu and Agaoglu, 1994). Two SO_2 generators comprising (1) polyethylene sachets with 15 ml of a 7% sodium metabisulfite solution and (2) SYS paper diffusers containing sodium metabisulfite powder were found equally effective in conserving grape quality for at least two months at 0°C temperature (Benkhemmar, *et al.*, 1993). SO_2 fumigation was very effective in reducing decay during ambient and cold storage of Campbell Early, Kyoho, Nuscat Bailey A, Tano Red, and Daebong grapes (Yun, *et al.*, 1995). The activities of catalase (CAT), SOD, peroxidase (POD) in grain, fruit stalk and spikelet stalk all increased when Thompson seedless grapes were fumigated with SO_2 for 1 h. The rate of membrane damage being lower with the lower concentration than the higher (Ge-Yiqiang, *et al.*,1998).

Grape guard inhibited fungal infection and discolouration of cluster stems and pedicels effectively during 45 days cold storage of Campbell early grapes (Kim, 1994). Red globe grapes can be stored for 6 weeks at 4°C with quick release grape guard. It reduced the incidence of decay and weight loss during storage (Castro, *et al.*, 1998). After 10 days of storage grapes inoculated with *Botrytis cinerea* and non-inoculated stored with UVAGAS or UVAS pods (Both are SO_2 releasing pads) were in sound and commercially acceptable condition (Mustonen, 1992). Postharvest fumigation of seedless table grapes (cv. Crimson seedless) with the natural volatile compound (E) -2-hexenal shows promise for decay control (Archbold, *et al.*, 1999). Potassium metabisulphite significantly reduced the decay losses in Thompson seedless grapes during storage and transportation when use as an in-package fumigant (2g/2kg grapes) (Mangasuli, *et al.*, 1998). Kosanova (1963) obtained the maximum storage of 97 days without damage to fruits by using sawdust mixed with metabisulphite and mustard. Malhi (1968) obtained best results using perforated poly-ethylene bags (150 gauge) containing 10 g each of potassium metabisulphite and silica gel (1:1). Efforts were also made to get uniform release of sulphur dioxide over required period by entrapping powdered bisulphite in various types of papers and plastic materials. Encouraging results were obtained with sodium bisulphate containing tissue paper packs or paraffin coated tubes in unvented containers (Nelson and Gentry, 1966). The release and distribution of sulphur dioxide was fairly uniform when potassium metabisulphite tablets were fixed under top and bottom pads (Nelson, *et al.*, 1969). No external, internal injuries, sensory disorders of berries or dicoloration of the peduncle and laterals were observed in fruit fumigated units methyl bromide and packed in PE bags with gas absorbent (Soma, *et al.*, 1991).

Possible alternatives of SO_2 have been investigated and include solution of ammonium bicarbonate and sodium bicarbonate, each with the addition of chlorine at 200 g/ml, which gave acceptable results; controlling O_2 and CO_2 levels; immersing fruit in ethanol, exposure to UV light and to ozone (Crisosto and Smilanick, 2002)..

Growth Regulators

Pre and post harvest use of growth regulators increased the shelf-life of fruits. Growth regulators reduces the loss in weight, spoilage percentage of respiration rate of fruits (Kumar and Gupta, 1988). Peroxidase and polyphenol oxidase (PPO) activities were markedly reduced with the pre-harvest application of NAA and GA (Kumar and Gupta, 1985a). Post-harvest berry shatter of Anab-e-Shahi grapes was reduced with a combination of α-NAA @ 25 ppm and 0.05% urea (Prakash, *et al.*, 1983). Singh (1979) reported that 100 ppm of PCPA was equally effective to that of α-NAA in controlling berry shatter in Himrod grapes. Pre-anthesis spray of gibberellic acid @ 20-40 ppm increased berry size, pedicel attachment and reduced berry shatter in Thompson seedless grapes during storage (Mavrikios, 1977). Spray of 100-150 ppm kinetin at pre-bloom and second rapid growth stage of berry development reduced berry shatter and other losses in stored Himrod (Dhillon, *et al.*, 1975) and perlette grapes (Randhawa *et al.*, 1976; Ladania and Bhullar, 1989). Application of Alar and CCC at 500-5000 ppm to perlette and Anab-e-Shahi Grapes reduced the storage losses due to weight loss, shatter and decay (Kahlon and Dhillon, 1980; Ladania and Bhullar, 1985; Dhillon, *et al.*, 1985). Medhi and Singh (1983) reported that polypheol oxidase activity reduced by 400 ppm GA treatment. The treatment of Alar, CCC, NAA and GA decreased total amino acids and increased protein content in different grape varieties during ripening and storage (Rao and Panday, 1975; Medhi and Singh, 1983b; Kumar and Gupta, 1985).

Perlette bunches dipped in cycocel 5000 ppm, GA_3 10 ppm and 25 ppm and kinetin 150 ppm were marketable upto 4 days of storage at room temperature (93.2°F±2°F) as cokmpared to 2 days in untreated bunches and also reduced berry rot and physiological loss in weight (Kumar and Chharia, 1990). Berry drop in Thompson seedless grapes, during harvest and storage was reduced by pre-harvest spray of GA_4 (Copper, *et al.*, 1992). Pre-harvest spray of Cycocel (1000 ppm) showed the least weight loss, reduced incidence of berry drop, berry rot and total spoilage during ambient storage (Singh, *et al*, 1989). Post harvest berry abscission in Kyoho grapes was inhibited by treating with GA and NAA and was promoted by ABA and ethrel (Wu, *et al.*, 1992). Spraying clusters (Flame seedless) with GA_3 (5, 10 or 15 ppm) before flower opening increased fruit quality and shelf life (Hammady, 1998). Pre-harvest and post-harvest treatments of GA_3 (25 ppm) and CPPU (5-20 ppm) delayed ripening during storage (0°C for 3-5 weeks) in Perlett; Superior and Thompson seedless grapes. CPPU decreased berry shatter and disease susceptibility also (Ben-Arie, *et al.*, 1998). Pre-harvest spray of GA_3 and kinetin at 25 or 50 ppm increased berry weight and increased the storage life upto 10 weeks (2 weeks longer than control fruits) (Hussein, *et al.*, 1998). Dormex treated Perlette vines recorded significanlty lower level of PLW and berry rot during storage (Dhillon, *et al.*, 1991).

Fungicides

Many field born and storage born pathogen causes the decay of fruits and leads to heavy economic losses. The post-harvest fungal decays is mainly caused by *Botrytis cinerea*, but depending upon the storage conditions other pathogen also cause losses (Fourie, 2008)

Various types of fungicides have been used to check these losses. Narasimhan *et al* (1968) and Subramanian *et al* (1973) reported that pre-harvest spray of 0.2% Captan reduced the decay of Anab-e-Shahi during storage. Pre-harvest applications of benomyl and TBZ each at 400 ppm were found to minimize *Botrytis* and *Penicillium* rots of Sultania grapes (Kokkalas, 1976). Pre-harvest sprays of Bavistin (300 and 600 ppm) and Captaf (0.2 and 0.3%) controlled decay of berries for 4-7 days under ambient conditions (Landania, 1986). Chadha (1985) reported that a waiting period of 30 days is required between spraying of Captan and harvesting. The antifungal solutions of ammonium lauryal sulphate and per-acetic acid were not effective in controlling storage rots of grapes (Andre, *et al.*, 1977).

The mixture of $CaCl_2$ 1.2%, Bayleton 0.025% and Topsin M @ 0.13% gave the best control of storage decay in cv, Muscat Hamburgsky and Moldova (Cooper, *et al.*, 1993). Pre-harvest spray of Dithane M-45 and Dithane Z-78 @ 0.2% improved the organoleptic quality, reduced the weight loss and decay of berries during storage (Pillania, *et al.*, 1993). Spray of iprodione (500 µg/ml) on grapes 65 days and 9 days before harvest markedly decreased berry shattering during storage at 5°C for 2 months (Ling, *et al.*, 1999). Sawant (2002) studied the effect of pre-harvest spray of Benomyl on post harvest decay of Thompson seedless grapes and found that pre-harvest spraying of Benomyl (0.05-0.10%) at 20 or 10 days before harvest effectively controlled post harvest decay (0.04-2.78% decayed fruits after 30 days of cold storage and 3 days of storage on shelves at 30-35°C). The post harvest treatment of Carbendazim, Captafol, Thiophanate-methyl, Mancozeb and Potassium metabisulphite were significantly effective in controlling spoilage of grape bunches during storage (Padule and Shinde, 1994).

Other Chemicals

Chemicals other than growth regulators and fungicides are also used to increase the shelf life of fruits. Calcium salts are the important chemicals which are used commercially in post-harvest handling of fruits. Calcium reduced the respiration rate and retards the other ripening processes (Kumar and Gupta 1985a). Total wastage of grapes as loss in weight, berry drop, berry rot was negatively correlated with calcium content (Kumar and Gupta 1985b). The quality of grapes appreciably increased during storage by pre-harvest spray of calcium nitrate (0.75%) (Kumar and Gupta 1985c; Kumar, *et al.*, 1990). 51.1% sound fruits were found after 8 days of ambient storage sprayed with a 6% $CaCl_2$ before harvest (Subburamu, 1990). Preharvest spray of $Ca(NO_3)_2$ reduced PPO activity and decreased the losses of tannins and ascorbic acid so that there was less internal browning of berries. The solute leakage was reduced and berry calcium content increased by upto 39% (Lu and Ouyang, 1990).

The best results were obtained with $CaCl_2$ 1.2% + 0.025%, Bayleton (spray 30 day before harvesting) during conventional storage of Muscat grapes for 3.5-6.5 months (Khitron and Lyublinskaya, 1991). Calcium application (1.5% $CaCl_2$ pre harvest spray) reduced polyphenoloxidase activity and symptoms of mechanical injuries, resulting in better appearance. Storage life was approximately 5-6 days. The weight loss of Kyoho fruits after 60 days of cold storage was reduced by both liquid Ca fertilizer (LCF) vine spray and cluster dipping treatments. Berry shattering of Kyoho and Campbell Early after 90 days of storage by LCF treatment was significantly decreased (Moon, *et al.*, 2003). Vapour phase hydrogen peroxide (VPHP) reduced the decay of Thompson seedless and red globe grapes by 73% and 28%, respectively after 12 days of storage at 10°C (Forney, *et al.*, 1991). With CT-3 (oxygen remover) (@ 2 g/kg of grapes) Longyan grapes can be stored satisfactorily for 98-126 days either in cold storage or in ordinary cellars, the amount of rotted berries did not exceed 6.25 (Lu, *et al.*, 1993). Sorbilen (ethylene absorbent) prolonged storage life by 1.7-2.5 time without noticeable loss in quality (Strel'-tsov, *et al.*, 1992). Wilting of pedicels and stalk, was less in F-6S-Al and F-6S-A_1 preservative treated Red Globe grapes than control and the disease incidence, rotten fruit rate and weight loss rate were also lower (Zhou, *et al.*, 1998).

Packaging

Packaging plays a vital role in the export trade of most of the commodities. Adequate packaging is necessary for the successful export of grapes. Grapes should be handled with utter care before and during packaging since there is danger of brusing and cracking of berries and destroying the attractive appearance of fruits. Gupta and Singh (1985) revealed that bamboo basket as package and paper cutting as cushioning material were found suitable for storage. The high density packs reduced shatter during handling (Nelson, *et al.*, 1970). In India use of paper lining with paper shreds cushioning in wooden and card board boxes reduced bruising and decay of grapes (Mir Ibrahim 1975; Sharma 1971; Singh and Kainsa 1983). The cellophane film of 60 µ thickness was effective in reducing weight losses (Dalgat, 1968). Polyliner of 100 gauge with 2 kg pack of perlette grapes with 20 perforations using - 'Dual Releases' SO_2 generator gave the best results (Dhillon and Sandhu, 1987).

Grapes packed in perforated plastic bags 'Ever fresh bags' could be stored for up to 6 weeks while maintaining good quality at 4°C (Castro, *et al.*, 1999). Kyoho grapes packed in PE film and Bio-PE film retained the excellent flavour upto 60 days of cold storage (0°C+90% RH) (Sangyoung, *et al.*, 1998). Grapes packaged under ambient conditions in LDPE and PP pouches maintained the Sensory qualities 7 days (Deshpande and Shukla, 2008). The best results were obtained when grapes were packed in boxes in a single layer without any packing materials. Storage losses were generally higher in large-capacity stores (150 t) than in those holding (25-40 t) (Dzheneev and Ivanchlnko 1991). Clusters of Wanhong and Aushan Hongbaoshi placed in 0.03 mm thick polyethylene bags with 4 strips of CT - 3 grape fresh-keeping agent and stored in a semi-underground mechanical cooling cellar, could be stored well for 150 days with 97.6% fine grade berries (Sushua, *et al.*, 1998). Anab-e-Shahi and Thompson seedless fruits packed in wire - bound boxes with fumigant had more firmness after 15 of storage in cool chamber (13.0-15.6°C + 85%RH) followed by cool store (1.8°C + 61% RH) and room temperature (23.3 - 24.4°C + 5.7%) as compared to fruits packed in CFB boxes with or without fumigant (Shankaraiah and Roy, 1991).

Storage

Low temperature storage/CA/MAP

Storage temperature, humidity and air composition governs the shelf - life and quality of fruits. Physiological loss in weight, respiration rate and decay percentage can be reduced by storing at low temperature. Siddapa *et al* (1954) successfully stored grapes for about 7 weeks in cold storage chamber at a temperature range of 0.0 to 1.65°C. Nelson (1955) reported that a temperature below 4.5°C retarded the development of all fungi and also checked stem desiccation, browning, berry softening and shatter. Gupta (1967) reported that at 1.1°C Anab-e-Shahi grapes can be stored for 70 days when wrapped in polyethylene bags along 1 g of sodium metabisulphite for 1½ kg of grapes. Storage life of Perlette, Thompson seedless and Beauty seedless can be extended upto 60 days at 1.7°C to 2.4°C and 85-90% RH, when wrapped in polyethylene bags containing 10 g each of potassium metabisulphite and silica gel (1:1) (Malhi 1968). Dhillon and Sandhu (1987) stored perlette grapes upto 40 days at 0-3°C and 85-90% RH. During the storage of grape cv Itelia the highest aldehyde and alcohol content were obtained under 5% CO_2 + 3.1% O_2 and 8% O_2 + 5% CO_2 conditions (Zhao, 2003). In cv. Agadai after 6 months of storage the total amino acid content had fallen by 17% in normal air but by only 7% in CA (8% CO_2, 5% O_2) storage (Mukailov, 1992). 114 volatile CA were found, when Agiorgitiko grapes were stored at 100% CO_2 for 10 days as where as only 60 were found in the control fruits (Dourtoglon, *et al.*, 1994).

Muscadine grapes can be stored for 3 weeks under cold controlled atmosphere storage conditions (20% CO_2 + 3% O_2 at 1-2°C temperature and 90-95% RH) with no appreciable damage (Basiouny, 1998). 8% CO_2 + 2-3% O_2 composition was the best for Muscat storage for 3-7 months (Khitron and Lyublinskaya, 1991). A combination of 10 kPaCO_2 with 3, 6 or 12 kPaO_2 is suggested for up to 12 weeks storage for late-harvested Red globe grapes. An atmosphere of 10 kPa CO_2 + 6 K PaO_2 it suggested for early harvested Red globe grapes, but not to exceed 4 weeks (Crisosto, *et al.*, 2002. Chlorine gas (Cl_2) produced by a salt mixture and combined with 25 days of storage at 0°C significantly reduced *B. cinera* decay in artificially inoculated flame seedless, Thompson seedless and Ribier grapes. No deleterious effect due to chlorine gas generation was observed. These results suggest that this is a sound alternative to SO_2 for post harvest control of decay. (Zoffoli, 1999). Fruits stored in modified atmosphere, zero energy chamber showed lowest physiological loss in weight and decay loss and maintained fruit quality. Whereas maximum PLW and decay loss were observed in fruit packed in unmodified atmosphere without diphenyl and kept at room temperature (Nain, *et al.*, 1999). Artes, *et al.*, (2003) stored the 'Napoleon' table grape in sealed plastic baskets up to 41 days at 0°C followed by 4 days in air at 0° and 3 days at 15°C. Microperforated polypropylene (pp) of 35 µm thickness and macroperferated polypropylene (MPP) films (as control) were used. Before sealing, soaked filter paper with 15 or 10 µl hexenal was added to baskets, steady state modified atmosphere (MA) was 17% O_2 and 3% CO_2. Best results for keeping 'Napoleon. quality during long-term cold storage were obtained by hexenal fumigation combined with MA.

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