Table Grapes
Postharvest Quality Maintenance Guidelines

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Scientific Name and Introduction

The table grape (*Vitis vinifera* L.) is a non-climacteric fruit with a relatively low rate of physiological activity, is subject to serious water loss following harvest, which can result in stem drying and browning, berry shatter, and even wilting and shriveling of berries. Gray mold, caused by the fungus *Botrytis cinerea*, requires constant attention and treatment during storage and handling. In California the major cultivars are Thompson Seedless (Sultanina) and Flame Seedless marketed mostly during the summer months up to 8-10 weeks after harvest. Present interest centers on other introduced seedless 'Fantasy' cultivars such as 'Ruby Seedless', and 'Crimson'. The seeded 'Red Globe', cultivar is becoming important late in the season.

Quality Characteristics and Criteria

High consumer acceptance is attained for fruit with high SSC or SSC/TA ratio. Berry firmness is also an important factor for consumer acceptance as are lack of defects such as decay, cracked berries, stem browning, shriveling, sunburned, dried berries, and insect damage.

Horticultural Maturity Indices

In California, harvest date is determined by Soluble Solids Concentration (SSC) of 14 to 17.5% depending on cultivar and production area. In early production areas, an SSC/TA ratio of 20 or higher is used to determine minimum maturity for cultivars that meet a low minimum SSC. For red and black colored cultivars, there is also a minimum color requirement.

Grades, Sizes and Packaging

Most California table grapes are being packed in the field. In contrast to South Africa and Chile, few grapes are shed packed. The most common field-packing system is the "avenue pack." The fruit is picked and placed into picking lugs. Usually, the picker also trims the cluster. The picking lug is then transferred a short distance to the packer, who works at a small and shape portable stand in the avenue between vineyard blocks.

Shed-packed fruit is harvested by pickers and placed in field lugs without trimming. Then placed in the shade of the vines to await transport to the shed. At the packing shed the field lugs are distributed to packers who select, trim, and pack the fruit. Often two different grades are packed simultaneously by each packer to facilitate quality selection. In some operations, trimming, color sorting, and a first quality sorting may occur in the field. In all of the systems, grapes are nearly always packed on a scale to facilitate packing to a precise net weight, whether field or shed packed. In general mid and late season grapes are packed in plastic bags or wrapped in paper. For early season grapes, bulk pack is mainly used. In all cases, packed lugs are subject to quality inspection and check weighing.

After packing and lidding, grapes are palletized, on disposable or recycled pallets. Some strapping in the field before loading is necessary in grapes packed in shoebox boxes. Often loaded pallets coming from the field pass through a "pallet squeeze," a device that straightens and tightens the stacks of containers. These pallet loads are unitized, usually by strapping or netting. Some palletizing glue is used in shedpacking operations. This glue bonds the corrugated containers vertically on the pallet so that only horizontal strapping is required.

Pre-cooling conditions

Cooling must start as soon as possible and SO_2 applied within 12 hours of harvest. Many grape forced-air coolers in California are designed to achieve 7/8 cooling in 6 hours or less. After cooling is completed, the pallets are moved to a storage room to await transport.

Optimum Storage Conditions

Ideally the storage room operates at -1^o to 0^{o}C (30^{o}C to 32^{o}F) and 90 to 95 percent RH, with a moderate airflow 20-40 CFM per ton stored grapes. The constant low temperature, high RH and moderate airflow are important to limit the rate of water loss from fruit stems. Fruit should be stored at -0.5-0^{o}C (31-32^{o}C) pulp temperature throughout its postharvest life.

Optimum Temperature

Storage temperature of -1.0 to 0.0^{o}C (30-32^{o}F) is recommended for mature fruit. Freezing damage may occur in less mature grapes. The highest freezing point for berries is -3.0^{o}C (26^{o}F), but freezing point varies depending on SSC. A -2.0^{o}C (28^{o}F) freezing point for stems has been reported for wine grapes. New table grape cultivars are more sensitive to stem freezing damage.

90-95% RH and an air velocity of approximately 20-40 feet per minute (FPM) is suggested during storage.

Controlled Atmosphere (CA) Considerations

CA (2-5% O_2 + 1-5% CO_2) during storage/ shipment is not currently recommended for table grapes because its benefit is slight and SO_2 is used for decay control. CO_2 at 10-15% in air can be used to control grey mold for up to 2-4 weeks (depending of cultivar). CO_2 at 5-10% can be combined with CA to provide decay control equally effective to SO_2.

Retail Outlet Display Considerations

Use of cold table during display is recommended.

Chilling Sensitivity

They are not chilling sensitive.

Rates of Ethylene Production and Sensitivity

<0.1 ? m l/kg ? hr at 20^{o}C (68^{o}F).

Table grapes are not very sensitive to ethylene.

Respiration Rates (of grape clusters, i.e. berries + stems)

Temperature	ml CO_2/kg•hr*
0^{o}C (32^{o}F)	1-2
5^{o}C (41^{o}F)	3-4
10^{o}C (50^{o}F)	5-8
20^{o}C (68^{o}F)	12-15

Stem respiration rate is approximately 15 times higher than berry respiration.

* To calculate heat production, multiply ml CO_2/kg•hr by 440 to get BTU/ton/day or by 122 to get kcal/metric ton/day.

Physiological Disorders

Shatter: (loss of berries from the cap stem). In general, shatter increases in severity with increasing maturity, i.e., the longer the fruit remains on the vine. Berries of seedless cultivars are usually less well attached to the cap stem than seeded cultivars. Shatter varies considerably from season to season, and there is a large difference among varieties. Gibberellin applied at fruit set weakens berry attachment. Shatter occurs mainly due to rough handling during field packing with additional shatter occurring all the way to the final retail sale. Shatter incidence can be reduced by controlling pack depth and fruit packing density (cubic inches per pound), using cluster bagging, gentle handling, and maintaining recommended temperature and relative humidity. Cane girdling reduces shattering incidence.

Waterberry: Waterberry is associated with fruit ripening and most often begins to develop shortly after veraison (berry softening). The earliest symptom is the development of small (1-2 mm) dark spots on the cap stems (pedicles) and/or other parts of the cluster framework. These spots become necrotic, slightly sunken, and expand to affect more areas. The affected berries become watery, soft, and flabby when ripe. In California, this disorder has been associated with a high nitrogen status vine, canopy shading, or cool weather during veraison and fruit ripening. Avoid over fertilization with nitrogen. Foliar nutrient sprays of nitrogen should be avoided in waterberry-prone vineyards. Trimming off affected berries during harvest and packing is a common practice, although labor intensive.

Postharvest Pathology

Gray Mold: (*Botrytis cinerea*). Gray mold is the most destructive of the postharvest diseases of table grapes, primarily because it develops at temperatures as low as 31^{o}F (-0.5^{o}C) and grows from berry to berry. Gray mold first turns berries brown, then loosens the skin of the berry, its white, thread-like hyphal filaments erupt through the berry surface, and finally masses of gray colored spores develop. Wounds on berry surface near harvest provide opportunities for infection. Although no wound is required for infection when wet conditions occur.

Removing desiccated infected grapes from previous season can reduce GRAY MOLD infection. Leaf-removal canopy management, pre-harvest fungicides, trimming visibly infected, split, cracked, or otherwise damaged grapes before packing is recommended. Prompt cooling and fumigation with sulfur dioxide (100ppm for one hour is essential to control gray mold during cold storage). Because of increased interest in the export market, there is a need to use SO_2 generating pads, especially for long-distance export marketing where grapes are in ocean transport for extended periods. These pads have sodium metabisulfite incorporated into them that releases SO_2 during transit and marketing.

Other diseases: Other pathogens become important at warmer temperatures, and they appear commonly sometime during transport or marketing after grapes are removed from cold storage. Black rot, caused by *Aspergillus niger,* blue rot, caused by *Penicillium* spp., and rhizopus rot, caused by *Rhizopus stolonifer* or *R. oryzae.* They are at least partially controlled by sulfur dioxide fumigation, although little research has been done to show this (Snowdon, 1990).

Sulfur Dioxide Use: Botrytis rot of grapes is not sufficiently avoided by fast cooling alone. It is standard practice in California to fumigate with sulfur dioxide (SO_2) immediately after packing followed by lower dose treatments weekly during storage. Formulas for calculating the initial and subsequent weekly SO_2 fumigation dosages using the traditional system are available (Harvest and Handling California Table Grapes for Market, Bulletin 1913, 1986; University of California DANR Bulletin 1932). Recently it has been demonstrated that the amount of sulfur dioxide gas needed to kill *Botrytis* spores, or to inactivate exposed mycelium is dependent on the concentration, and the length of time the fungus is exposed to the fumigant. A cumulative concentration, calculated as the product of the concentration and the time, called "CT product", describes the sulfur dioxide exposure needed to kill the decay organism. A CT of at least 100 ppm-hour is the minimum required to kill spores and mycelium of *Botrytis* at $0^{o}C$. This finding was the basis for the development of the total utilization system. Total utilization often uses about half as much sulfur dioxide as the traditional method and improves uniformity and effectiveness of SO_2 fumigant. In this total utilization system, the first fumigation is done in conjunction with forced air cooling. The forced air flows through the boxes and ensures good penetration of sulfur dioxide even to the center boxes on a pallet. In most combinations of boxes and packs, this system produces over 80% penetration, measured as percent of the room air CT product. The storage fumigation process is applied every 7-10 days. Details on this work are contained in the previously cited Bulletin 1932.

During ocean shipment for periods longer than 10 days or long retail handling in which SO_2, fumigation cannot be applied, the use of SO_2-generating pads in combination with a box liner is advised. These SO_2-generating pads have sodium metabisulfite incorporated into them to allow a constant and slow release of SO_2 during shipment and marketing. In California, the slow-release SO_2 generating pad used combined to a perforated polyethylene box liner (1/4" hole, 3" or 4" center) reduces water loss and assures gray mold control without enhancing SO_2 phytotoxicity (Crisosto et al., 1994).

Quarantine Issues

Issues associated with exotic pest quarantines, either addressing imported or exported table grapes, can change rapidly. Rules regarding import requirements are issued by the USDA Animal Plant Health Inspection Service (USDA-APHIS). This agency provides information to assist exporters in targeting markets and defining what entry requirements a particular country might have for table grapes. USDA APHIS, in cooperation with the State plant boards, developed a data base, called Excerpt, to track the phytosanitary requirements for each country. USDA APHIS also provides phytosanitary inspections and certifications that declare the grapes are free of pests to facilitate compliance with foreign regulatory requirements.

Grapes imported into the United States from other parts of the world are routinely fumigated with methyl bromide, following treatment schedules issued by the USDA APHIS, to prevent the entry of insect pests. Cold treatments are also accepted by USDA APHIS for the control of fruit flies. Of primary concern are the vine moth, *Lobesia botrana,* the

Mediterranean fruit fly, *Ceratitis capitata,* and miscellaneous external feeding insects.

Grapes exported from the United States may harbor pests of concern elsewhere, but they rarely require treatment, although this situation can change rapidly. Black widow spiders are occasional hitchhikers within grape clusters or within grape boxes; SO2 fumigation, alone or combined with carbon dioxide, has been used successfully to kill the spiders before export. Omnivorous leafroller, *Platnota stultana,* is found on grapes in California, and has the potential to be a pest of regulatory concern on table grapes exported to counties where this pest is not found. Two methods to control this pest, insecticidal controlled atmosphere treatment (Ahumada, et al 1996), and low temperature storage combined with SO2 slow-release generators (Yokoyama et al 1999), have been developed to control this pest.

Suitability as Fresh-cut Product:

Grapes are well adapted to a stemless packaging system.

Special Considerations

Market life varies among table grape cultivars grown in California and is also strongly affected by temperature management and decay susceptibility.

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Acknowledgments

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