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COLD STORAGE OF TABLE GRAPES

SOFRALIK ÜZÜMLERİN SOĞUKTA MUHAFAZASI

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ÖZET: Hasat edildikleri mevsimler gözönüne alındığında, üzümlerin günün erken yani serin saatlerinde hasat edilmeleri, hasat edilen üzümlerin güneşe maruz bırakılmamaları, ambalajlamanın dikkatli bir şekilde yapılması ve hasattan sonra kısmi bir önsoğutma işleminin gerçekleştirilmesi gibi hasat öncesi ve sonrasındaki işlemler, sofralık üzümlerin muhafazasında üzümlerin hasat edildikleri zamanki kalitelerinin korunabilmesi için öncelikle uygulanması gerekli tedbirler olarak bilinmektedir.

Sofralık üzümlerin muhafaza sürelerini ve kalitelerini etkileyen en önemli faktörler; su kaybı ve Botrytis cinerea, Penicillium sp. ve Alternaria gibi zararlı mikroorganizmalardır. Üzümlerin muhfazasında su kaybını minimum düzeye indirebilmek için düşük sıcaklık ve yüksek nispi nem koşullarının depo içerisinde sağlanması gereklidir. Buna ilave olarak, üzümler yukarıda belirtilen zararlı mikroorganizmaların meydana getirdiği çürüme ve bozulmaları engellemek amacıyla hasattan hemen sonra ve depolama süresince SO2 ile fümige edilirler.

Sofralık üzümlerin muhafaza ömürleri sıcaklık, nispi nem hava hareketi ve SO2 ile fumigasyon gibi faktörler tarafından etkilenmektedir.

Bu makalede, sofralık üzümlerin muhafaza sürelerini etkileyen faktörler, sofralık üzümlerde hasat sonrası zararları önleme metodları, üzümlerde kullanılan fumigasyon yöntemleri ve teknikleri açıklanmıştır.

ABSTRACT: Good harvest practices, such as picking early and cool hours, as well as avoiding exposure of the fruit to the sun, careful packaging and particularly promt cooling after harvest, all these are known as prerequisite conditions to ensure a good keeping quality of all varieties during storage.

The most important factors influencing the length and the quality of the storage of table grapes are water loss and decay causing fungi, namely Botrytis cinerea, Penicillium and Alternaria sp. Low tempeature and high relative humidity are required to minimize the water loss during storage of table grapes. In addition, grapes are fumigated with sulphur dioxide soon after harvest and during storage to reduce spoilage caused by decay organisms mentioned above.

Storage life of table grapes in the storage environment is influenced most directly by temperature, relative humidity, air movement and fumigation with sulphur dioxide.

In this article, factors affecting storage life of table grapes, prevention methods of post-harvest decay of table grapes, fumigation methods and techniques for storage of table grapes are explained.

INTRODUCTION

The most important factors affecting length and the quality of the storage of table grapes are water loss and decay-causing fungi. High relative humidity is necessary to minimize moisture loss and maintain stem in good condition. In addition, low temperature is necessarry also to reduce the respiration rate by this way also to minimize water loss.

Grapes are very perishable commodities, and the different cultuvars react differently to cold storage. Length of storage is therefore limited by certain factors. In such conditions, handling, packing and special cooling methods are essential for the delivery to the consumer may range from some days to a month.

It was stated that fruits may be cold stored to extend the marketing period or torelieve temporary market congestion. With grapes, extending the marketing period is by far the more important object. Its importance has increased with improvement in the storage environment. Improvoments have resulted from advances in the procedures of precooling, more effective use of sulphur dioxide, better temperature and humidity control and more appropriate handling of the grapes.

Storage life of table grapes in the storage environment is affected most directly by temperature, relative humidity, air movement and fumigation with sulphur dioxide.

Temperature : The lower the storage temperature, other conditions being favourable the longer the fruit may be held. However the danger of freezing determines the lowest temperature that may be used to prolong the life of the fruit. Although the fruit of the most varieties, when they are well mature, will not be damaged by storage temperature as low as –3.8°C. Stems, which are always lower in sugars, will be injured at higher temperature. Thus, to provide a margin of safety in storage plant operation and to allow for normal temperature variation. Present recommendation are (-1.1°C) - (0°C) (DEBNEY et al. 1980; SALUNKE and DESAI, 1984; SEELIG, 1968; WINKLER et al. 1974).

Temperature maintanance is facilitated by the manner in which the continers are arranged in the storage rooms. In most of the storage plants, the grape lugs are stucked, on pallets, with the pallet loads stacked three high -to the ceiling. Two principles must be observed; the side of the lugs should be in the direction of the air movement and according to RYALL and HARVEY (1959), the spacing between rows and between pallets must be uniform. Heat transfer is accomplished more readily from the thin, partially openside of the lug than through the thicker, solid ends. Uniform spacing of the rows and pallets is necessary for even distribution of air and the maintanance of uniform temperature.

Relative humidity: The relative humidity should be high in grape storage rooms, as close to saturation as possible. High relative humidity is necessary to minimize moisture loss and maintain stems in good condition. Warm air holds more water vapour then cold air; for instance, air of 80% relative humidity at 23.8°C contains much more water by weight than air of the same relative humidity at 1.6°C. As the relative humidity of the air in a storage room increases, the vapour pressure increases and water loss from the grapes decreases. That is why a relative humidity of 92 to 96% is recommended for grape storage rooms (ABRAHAM, 1985; O'BREIN et al. 1983; HARDENBURG et al. 1986).

Different temperatures and relative humidities recommended for storage of table grapes cvs are shown in table 1.

Table 1. Various Temperatures, Relative Humidities and Storage Periods of Table Grapes During Cold Storage

CULTIVARS	STORAGE TEMPERATURE(°C)	RELATIVE HUMIDITY (%)	STORAGE PERIOD M:month, W:week, D:day	SOURCES
Generally	-1.1.to 0.5	90-95	-	RYALL and PENTZER, 1982; WEAVER 1976
Generally	-1.0 to +1.0	90-95	-	WINKLER et. al. 1974
Generally	-2.0 to +2.0	86-92	-	THYSCENKO, 1974
Generally	-1.0 to 0	85-90	1-6 M	MITTEN, 1976
Generally	-1.0 to 0	92-96	-	SALUNKE and DESAI, 1984
Generally	-1.0 to 0	90-100	-	DEBNEY et al. 1980
Generally	-1.0 to 0	90-95	-	SEELIG, 1968
Grapes;				
Vinifera	-1.0 to -0.6	90-95	3-6 M	HARDENBURG et àl. 1986
Vinifera	-1.1 to -0.6	88-92	3-6 M	BANVART, 1981
Vinifera	-2.0 to -1.0	88-92	3-6 M	DESROISER and DESROISER 1977
Vin. (European) or Calif. Grapes	-1.1 to -0.5	87-92	-	HALLOWELL, 1980
American	-0.6 to -0	85	14-56 D	HARDENBURG et al., 1986
American	-0.6 to -0	80-85	3-8 W	BANVART, 1981
American	-1.0 to 0	80-85	3-8 W	DESROISER and DESROISER 1977
Müşküle cv.	-1.0 to 0	90-95	3-4 M	TÜRK, 1987
Concorde type	-1.0 to 0	85-90	3-4 W	AĞAOĞLU et al., 1987
Chasselas, Muscat, Sultanina	-1.0 to 0	85-90	2 M	AĞAOĞLU et al., 1987
Verigo and Mavro cvs.	-1.0 to +2.0	85	3.5 M	KOKKALOS, 1977

Air movement : One of the most important factors influencing the storage life of grapes is air movement. Air movement within a storage room should be only enough to remove vital heat and the heat that leaks in the room (SALUNKHE and DESAI, 1984). Ample air movement in a well-insulated, tight room is to 10 to 25 linear feet per minute. More than 25 feet per minute only causes to product shrinkage. It has been shown doubling the air movement increased moisture loss by about one third and was equivalent to a drop of about 5% in relative humidity (WINKLER et al. 1974).

TÜRK (1987), suggested that air movement in storage room between 0.2-0.4m/second is ample in respect to decrease of moisture loss. HARDENBURG et al. (1986) stated that high relative humidity is necessary to minimize moisture loss and maintain stems in good conditions. When grapes lose 1-2% or more water by weight, their apparance is adversily affected.

Disorders: During cold storage, grapes are susceptible to rot caused by the fungi *Botrytis cinerea* Pers., *Cladosporium herbarum.*, and *Alternaria sp.* Grapes therefore are fumigated which aims primarly toward control of decay caused by fungi; mentioned above, which are capable of growing at the storage temperatures used for them (AĞAOĞLU et.al. 1988; BALLINGER and NESBITT; 1982; CHILDERS, 1988; ERİŞ and TÜRKBEN, 1984; GÖKÇAY, 1976, 1979; HARVEY and UOTA, 1978; SAMANCI, 1985; TÜRK, 1984, 1987; WINKLER et. al. 1974).

The fungus which occurs most frequently, however, is *Botrytis cinerea.* The *Botrytis cinerea* fungus grows on a host of dead organic substances commonly found in all vineyards. The fungi produce spores under favourable conditions. The spores readly become air-borne and some of them come to rest on the grapes. Those spores germinate when conditions are favourable. Optimum temperature for germination of Botrytis is given as 20°C (68 F); it loses its viability at 43.3 °C (110 F). Free moisture and a high atmospheric relative humiditiy greatly accelerate germination of the spores, which eventually causes the rot. It is well known that skin injures fruit. Examination of stored grapes show tight bunches are generally very susceptible to Botrytis rot. Because certain inner berries become crushed and release free juice. (COMBRINK and GINSBURG, 1972; ERİŞ and TÜRKBEN, 1984; GINSBURG, 1965).

Botrytis causes rot generally known as slip-skin, which is the name given to the condition of Botrytis rot during its early development. The decay starts when its spores germinate on the surface of a grape berry. Then, the fungus penetrates through the skin, attacks the berry tissue below the surface and kills the cells. As soon as this happens, the slightest pressure on the berry will cause the skin to crack and slip away from the underlying tissue; hence the name slip-skin. This stage is also accompanied with a browning of the skin colour, which is the best seen in white grapes. Gray mould rot is but another name for Botrytis rot and stems from the greyish colour found when the fungi sporulates on the surface of the berries. Gray mould, *Botrytis cinerea*, is capable of causing severe destruction of grapes even at low storage temperatures (COMBRINK and GINSBURG, 1972; ERİŞ and TÜRKBEN, 1984; WINKLER et al. 1974).

PREVENTION METHODS OF POST-HARVEST DECAY OF TABLE GRAPES:

With a varying degree of success againist Botrytis rot, a numerous of chemicals such as Isomaltol, dibromo-tetrachloro-ethane (D.B.T.C.E.), Iodine, Orthophenylphenol, Acetic acid, Formaldehyde, and chlorine compounds have been tested. However, these materials were applied in several ways and some measure of control was achived. Side-effects such as tainting and a general drop in quality prevented commercial application of these substances.

FUMIGATION WITH SULPHUR DIOXIDE (SO_2):

Exposure of table grapes with SO_2 to control decay causing organisms has been practiced for more than 50 years successively. When *Botrytis cinerea* is treated with SO_2 the subsequent reduction in spore germination is quantatively proportional to the sulphur dioxide contentration and the exposure time.

Most of the researchers agree that fumigation with sulphur dioxide kills fungus spores present on the surface of the fruit, but it does not kill infections which may have occured in the vineyard prior to harvesting (HARVEY and UOTA, 1977, 1978; HARDENBURG et. al. 1986; PEISER and YANG, 1985; SEELIG, 1968; WINKLER et al. 1974).

Such infections continue to develop within individual berries, during storage, but fumigation reduces the spread of decay from infected to adjacent berries and prevents the formation of "nets" of mouldy berries.

Consequently, after several weeks of storage individual berries may be found that have completely decayed inside and have mummified as a result of Botrytis rot without having infected adjacent berries.

Fumigation with sulphur dioxide reduces also the rate of respiration of grapes. It was found that the respiration rate of Empereror grapes containing only 22 ppm of SO_2 was reduced to 82% of normal at 0°C with 87 ppm SO_2, their respiration was reduced to 8% of normal, but high SO_2 concentration severely damaged the fruit (SALUNKHE and DESAI, 1984).

Sulphur dioxide is also beneficial to the stems, causing them to bleach slightly and retain a light green or amber colour. Without fumigation, the stem darken, become unattractive, and may support the growth of Blue mould (penicillium sp).

By helping to maintain stem and pedicel condition, fumigation reduces the tendency of berries to shatter or drop from the cluster during shipment (GÖKÇAY, 1979; HARVEY and UOTA, 1978; SEELIG, 1968; WINKLER et. al. 1974).

Fumigation with SO_2 is performed in small rooms, in precooling rooms, in storage, in the transport vehicle or within individual packages. Various combinations of these methods also may be used.

Storage Fumigation

In the initial fumigation dose recommended under favourable conditions is various from 0.5 to 1.0%. The aim is to maintain this dosage for 20 minutes and then to purge the SO_2 from the atmosphere.

However, a dosage of 0.5 % SO_2 applied for 20 minutes is in most cases adequate for the initial dosage (GINSBURG, 1965; GINSBURG et. al. 1978; HARDENBURG et al. 1986; SALUNKHE and DESAI, 1984; SEELIG, 1968; WINKLER et al., 1974).

To accomplish this the absorptive capacity of the lugs and fruit as well as the space they occupy must be taken into account.

Nelson and Baker (1963), found the SO_2 may be determined with the following formula;

$A = (BxC)/D + (ExF)$

When

A = the pounds of sulphur dioxide required

B = the percent concentration of sulpur dioxide desired

C = the cubic feet of free space of the room 9 (total cubic feet of the room minus 0,5 food for each lug of fruit).

D = the volume occupied by one pound of sulphur dioxide gas.

E = the pounds of sulphur dioxide absorbed by each carload unit of packed lugs of grapes (each carload unit consisting of 1000 lugs, each lug containing 22-26 pounds of fruit).

F = the number of carload units of fruit.

As far as the fumigation with SO_2 is concerned for uniform treatment it is necessary that the sulphur dioxide be throughly mixed with the air and distributed quickly and evenly to all parts of the room. These should be as gas outlet in front of each room fan. Proper container alignment and adequate fan capacity are necessary for uniform fumigation both at the initial treatment and during refumigations. The lugs should be oriented parallel to the air flow with channels 3/4 to 1 1/2 inches on each size and extended unobstructed completely through the stack of fruit (WINKLER et al. 1974).

After the 20 minute exposure of the grapes to SO_2, teh residual SO_2 is removed from the storage room by means of blowing it out through appropriate ceiling vents, or by passing it through the water spray used as the refrigerant. If so, the water must be neutralized from time to prevent to build up of sulphurous acid which is very corrosive (WILLS et al. 1982).

Researchers have shown that this initial SO_2 treatment can only be relied upon to hold the *Botrytis cinerea* infection in check for seven to ten days. If grapes have to be held for longer than a week, additional fumigation must be applied to every seven to ten days. The dosage recommended for the second and subsequent treatments is 0.25 % sulphur dioxide concentration for 20 minutes (GINSBURG, 1965; HARVEY and UOTA, 1977; HARDENBURG et al. 1986).

In practise, stored grapes are usually fumigated at approximately weekly intervals. The gas concentrations in the atmosphere may be either manually or automatically controlled. In the case of manual control the gas is led from a cylinder of liquid SO_2 through an automatic expansion valve then through a needle valve, using 6 mm copper tubing, and in to a transparent water or oil trap.

The rate of SO_2 delivered from the gas cylinder is judged by counting the bubles rising from the liquid trap. The gas line then continues form the liquid trap to the cold store where the SO_2 is released into the air delivery stream (Figure 1).

USE OF BISULPHITE FOR FUMIGATION

It was indicated that the benefits of SO_2 gas fumigation largely dissappear after a short period. WINKLER et al. (1974) stated that it is not possible to retreat with gas in sawdust packs and lugs packed for immediate export, and it is also not possible to fumigate the ship holds because of presence of other fruits and storage materials that would be damaged. Under these circumstances, bisulphite can be used for fumigation. The bisulphite treatments overcomes most of the objections to the sawdust chest, namely the higher cost occasional off odours, and unattractive appearance.

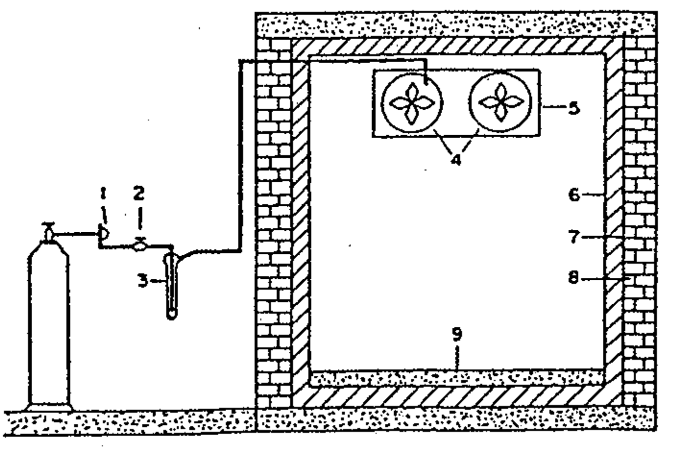

Figure 1. **Diagram of a cold store for table grapes in which SO_2 is maintained by means of a manually controlled system. 1. expansion valve, 2. needle valve, 3. oil trap, 4. fan, 5. corrosion resistant cooling unit, 6. insulation, 7. vapour barrier, 8. wall, 9. concrete**

As the chemical reacts with moisture it give off SO_2. The rate of SO_2 evolution is dependent upon the amount of moisture present. Too much moisture causes too rapid a release of the gas so that the fruit is bleached and no gas is left for the latter part of the storage period.

Tablets or packed incorporating various materials, i.e. aluminium sulfate or slica gel, with sodium bisulfite have been effective in controlling the release of SO_2, and have been particularly effective for decay control when used in combination with polyethylene box liners (FIDEGHELLI and MONASTRA. 1968; NELSON et al. 1969).

FIDEGHELLI and MONASTRA (1969), places 10 grams of bisulphite dissolved in 140 cc of H_2O, in a number of PE sachets which were placed on top of the grapes in a 10 kg pack. The PE (polyethylenes) sachets were 0.05 mm in thickness. The treated one (pack) was placed in a ventilated PE bag which was 0.1 mm in thickness. They stated that this treatment prolonged the storage life of Italia grape twice. The rate of SO_2 release could be further conrolled by using sachets having different wall thickness or a higher or lower concentration of the bisulphite. They also found that including a PE bag of potassium metabisulphite solution in the boxes completely controlled Botrytis rot of stored grapes (FIDEGHELLI and MONASTRA, 1974; WINKLER et al. 1974).

KOKKALOS (1977), indicated that $K_2S_2O_5$ (potassium metabisulphite) at 5-10 g/8.5 kg box reduced decay, caused by *Botrytis cinerea* and *Penicillium sp.* of Sultanina and Razaki grapes for 5 days after removal from 12-day storage at 0°C and 85 % relative humidity. SIMENOVA and BOZHINOVA (1977), found that small containers holding a 6.67 % water solution of potassium metabisulphite placed between the packs caused to retain a good flavour with a low content of free and bound sulphur dioxide during storage of Bolgar and Dimyat cvs. AĞAOĞLU et.al. (1988), indicated that Sultani Çekirdeksiz cv. could be stored for 75 days with 10 g $K_2S_2O_5$/8 kg as for Müşküle cv. could be stored for 120 days with 10 g $K_2S_2O_5$/8 kg applications without any decay.

GRAPE GUARD PADS

Grape guard pads were developed in U.S.A. in the late 1960's and are now made under licence by UVAS Quality Packaging Inc., California. The pirincipal is similar to that already described above, except that sodium metabisulphite ($Na_2S_2O_5$) powder is used instead of solution. Varying quantities of the powder are qlued between two strips of paper, forming a pad. There are two types of pads available the quick release pad and the combination pad (slow release). In the case of quick release pad, initial fast release of SO_2 is obtained, which gives protection for up to three weeks, and followed by a slower release to control decay for up to 12 weeks. With both pads, moisture within the box of grapes is absorbed to react with a compound which releases SO_2. The quick released pad is a 200 mm x 400 mm sheet of brown paper coated on the side with the SO_2 releasing compound. With the standart 10 kg carton or box, two pads are required, one on the bottom and the other on the top of the grapes. It is important that to place the brown, uncoated side of the pad away from the grapes. The combination pad is a combination of a quick release pad a slow release section consisting of SO_2 releasing chemical enclosed in heat sealed pouches. These are used at the same rate as the quick pads i.e. one pad /5-6 kg of grapes.

This method also required good temperature control to prevent the excessive release of SO_2 which will occur if fruit temperatures are allowed to rise. This can easily happen during loading, transport and at the market place, and can only be avoided by removing the pad or reduced by slitting the polyethylene bags (COMBRINK and GINSBURG, 1972; DESROISER and DESROISER, 1977).

SÖYLEMEZOĞLU (1988), indicated that Sultani Çekirdeksiz cv. grown in Turkey could be stored for 105 days with "Slow-release SO_2 generators + perforated PE/6-8 kg, and 10 kg" and "Slow release SO_2 generators + unperforated PE/6-8 and 10 kg" treatments, whereas Müşküle cv. colud be stored up to 120 days by using "slow-release SO_2 generators + unperforated PE/6 and 8" and "Slow release SO_2 generators + perforated PE/10 kg" treatments.

FACTORS AFFECTING ABSORPTION OF SULPHUR DIOXIDE

Absorption of sulphur dioxide is influenced by a number of factors such as variety, maturity, temperature of the fruit, concentration of the SO_2, and time of exposure to the gas.

Some varieties absorbed sulphur dioxide much more rapidly than others. For instace, from the same concentration of gas, Thompson seedless absorbed as much in thirty minutes as Gros Gullaume did in sixty minutes. Similarly, different varieties tolerate different amount of SO_2 without injury. Emperor showed commercial injury at 14, Malaga at 18, Muscat of Alexandria at 26, THompson Seedless at 30 ppm, and Gros Guillaume at 65. It was also stated that appreciable variation within a variety in different vineyards and seasons (WINKLER et. al. 1974).

Maturity is another fackor affacting absorption of SO_2. Immature grapes absorb SO_2 more rapidly than mature ones do. For instance, Muscat of Alexandria grapes of 27°C, 18°, and 13° brix, respectively, absorbed 43, 77 and 262 ppm. These results indicate that for uniform fumigation the grapes should be uniform in maturity.

As far as factors affecting absorption of SO_2 are concerned, warm grapes, absorb more sulphur dioxide than cold grapes from the same concentration of the gas in a given time. Thompson seedless absorbsed twice as much SO_2 at 22.2°C (72°F) as at 3.8°C (39°F). WINKLER et. al. (1974), stated that the temperature is of particular importance when precooled grapes and grapes directly from field are fumigated together.

Grapes absorb more sulphur dioxide when they are exposed to high concentration and long exposure. The most important factors far uniform fumigation are the concentration, speed of entry into the room, fan distribution and time of exposure. The concentration of SO_2 must not only be a compromise between that which will provide acceptable control of decay and that which will not cause excessive injury but also be uniform throghout the room. The balance between SO_2 conncentration that control decay, but do not cause injury is delicate. This situation is shown in figure 2 (HARVEY and UOTA 1978, WINKLER et. al. 1974).

There are also some other factors influencing the selection of particular SO_2 concentration. These are relative humidity on the storage room, air movement within the room, the decay potential of the fruit, and the type of package used.

The high relative humidity is used to reduce desiccation of the fruit. It increases the amount of SO_2 removed from the free air space around the grapes. However, if the grapes are packed in polystyrene foam boxes little or no SO_2 is removed during fumigation and the total amount of SO_2 needed is less than that for grapes packed in wooden boxes (Figure 3).

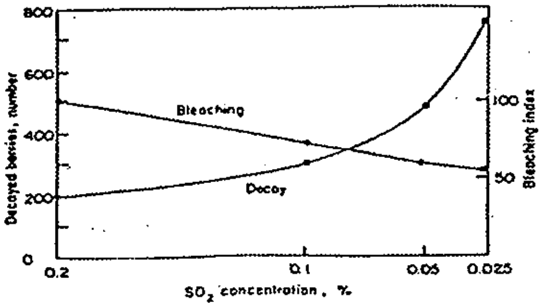

Figure 2. **Effect of concentration of weekly SO_2 fumigations on decay and bleaching Thompson Seedless grapes stored 120 days.**

It was also stated that high moisture conditions increase the toxicity of SO_2 to the spores of *Botrytis cinerea* and *Alternaria sp.*

The air velocity required for uniform and adaquate penetration of SO_2 in to grape packages is much higher than that needed to manitain proper temperatures in storage. It was reported that a velocity of 15 $mmin^{-1}$ was needed for grapes in standart boxes with liners, but that 23 $mmin^{-1}$ was necessary if paper curtains or cluster wraps were used (HARVEY and UOTA 1978).

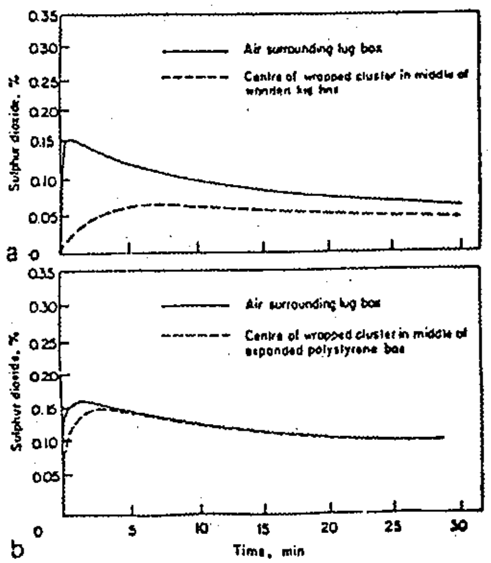

Figure 3. **Effect of packing material on the concentration of SO_2 in a grape box a. wood, b. expanded polystyrene**

PRECAUTIONS IN FUMIGATIONS

It is easy to recognize the purgent odour of even at very low concentrations. At 400 ppm the gas is extremely irritating and causes injury to the tender tissues of the nose, eyes, and mounth. At the concentration used for fumigation in storage rooms it can cause respiratory spasms and death if the victim can not escape to fresh air. It was suggested that if it is necessary to enter a room with even a very dilute concnetration of sulphur dioxide, googles and mask must be worn. The mask must be effective againist acid-type gases (WINKLER et al. 1974).

SO_2 injury

High concentration of SO_2 can cause damage of the grape. This damage is visible as depressed and white bleached areas where the gas penetrates the berry and causes a bleaching of stems. Belaching is the most common type of SO_2 injury in grapes. This injury is always most pronounced around the pedicel (WINKLER et al. 1974).

Another symptom of SO_2 injury is wetness of grapes that refers to the accumulation of droplets of juice on the surface of the berries and pedicels. It is cused by the leakage of juice from the berries through microscobic mechanical injuries. SO_2 penetrates such injuries and damages tissues beneath them. When the exuded juice dries, the berry surface assumes a shiny, varnished, unsightly appearance, sometimes confused with freezing damage (KADER et al. (1985).

If too high SO_2 concentrations are applied to the grapes, the grapes will develop malflavour. It was also stated that the grape difers from all other fruits in its tolerance of SO_2. It has a detrimental effect on other fruits and vegetables in the same cold store. Therefore it is not feasible to keep them in the same storage house with other commodities (DE SWART and LOUW 1968).

As far as the SO_2 injury is concerned, it has also an eroding effect on untreated metal parts if the gas combines with water to form a sulphurous acid. This problem can be overcome by covering all metal parts in cold stores with an acidic-resisting paint (DE SWART and LOUW, 1968; WINKLER et al. 1974).

OTHER TECHNIQUES FOR STORAGE OF TABLE GRAPES

Controlled Atmosphere (CA)

It was stated that CA are not used commercially for table grapes. This method generally has little benefit for furit with a nonclimacteric respiratory pattern, such as grapes. Researchers have shown that CA alone does not control decay, unless the carbon dioxide levels are increased or the oxygen levels are reduced to the point where physiological disorders may occur. Only fruit in treatments that included SO_2 was in good condition after storage. Fumigation with SO_2 also reduces the respiration rate of grapes during storage (HARVEY and UOTA, 1978). It was also indicated Waltham Cross, and Barlinka cvs. stored under CA conditions did not respond to these conditions like apple and pears.

The standart storage method based on SO_2 treatment offered better protection and as a result induced less total losses during storage than the CA storage combinations.

Irradiation

There are different opinions concerning the use of gamma rays to control decay. Although good results have been obtained with irradiation, commercial application of this technique are unlikely. Irradiation causes biological changes in thee fruit that may possibly be transmitted to the consumer. This technique is one which may have some promise, although its application may still be long way off (COMBRINK and GINSBURG, 1972).

Thompson Seedless grapes were irradiated to O (control) 1, 2, 3, 4, and 5 x 10^5 rd and were stored at 4.4°C for one month. It was included that fruits irradiated to 1 and 2 x 10^5 rd were welll liked and in marketable condition up to one month (Figure 4).

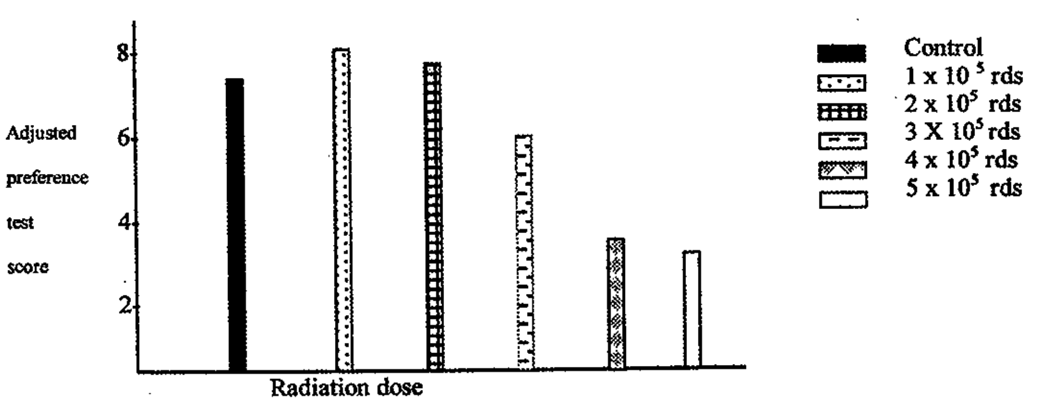

Figure 4. **Effects of radiation dose on the "adjusted taste preference score" for Thompson Seedless grapes stored at 4.4°C and evaluated after one month**

The Fruits irradiated to-3,4 and 5 x 10^5 rd, however, turned unmarketable due to the development of a deep brown colour. The browning was attributed to the possible activation of certain enzymes by the higher doses of irradiation. There was no mold an off-flavour in all treatments up to 3 months, while the control fruits were not edible due to the profused development of mold (SALUNKHE and DESAI, 1984).

Short Term Storage

Cooling guaranties tha maintenance of grape quality and is justified even when the time between harvesting and marketing is only a few days. The more delicate the cultivar, the greater the necessity for cooling. If the facilities for maintenance of the cold chain are available and reliable the grape temperature should be reduced to 5°C. Weak links of the present in the cold chain, especially at retail outlets where the grapes are displayed for sale at ambient temperature. Under such conditions the grapes should be cooled to just above the dew point to avoid water condensation on the grapes; free water at a relatively warm temperature of approximately 20°C is conductive to the development of decay. It was stated that storage for periods from a week to a month requires pre-cooling to the storage temperature of –0.5°C at a relative humidity of 95 % and higher if possible. As it is mentioned before one of the following methods in generally used for decay control; emission of SO_2 gas from a cylinder of liquid SO_2; emission of SO_2 from bisulphite powder placed in the grape pack; spraying a pre-determined amount of a meta-bisulphite solution on top of a top sheet of absorbent paper covering the grapes (GINSBURG et al. 1978).

Long Term Storage

The presence of increased cold store facilities in the grage production area, could well lead to greater volumes of grapes being stored for out of season marketing.

Cultivars known to possess good keeping qualities are pre-cooled as soon after harvesting and packing as possible and stored according to one of the following two methods:

Intermittent SO_2 application at weekly intervals as already described for short term storage of grapes; the grapes are stored at –0.5°C in an atmosphere containing 8 to 13 ppm SO_2.

The gas concentration in the atmosphere may be either manually or automatically connected (BANWART, 1981). Manually control is shown in figure 1.

Underlight of these knowledges the key to successful table grape storage remains efficient decay control. SO_2 controls decay relatively effectively but its undesirable properties dictate that future research be directed at finding a substrate which is not phyto-toxic to grapes.

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