IMPORTANCE OF PRE-COOLING ON THE STORAGE OF TABLE GRAPES

SOFRALIK ÜZÜMLERİNİN MUHAFAZASINDA ÖNSOĞUTMANIN ÖNEMİ

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ÖZET: Önsoğutma üzümlerin hasat edildikleri zamanki sıcaklıkların mümkün olduğu kadar kısa süre içerisinde muhafaza edilecekleri sıcaklığa düşürülmesidir. Üzümlerin önsoğutmaya tabi tutulmalarının en önemli sebebi su kaybını minimum düzeye indirmektir. Bu ise fiziksel bir faktör olan üzümlerin muhafaza edildiği ortam havasının evaporasyon potansiyeline bağlıdır.

Bu makalede üzümlerde kullanılan önsoğutmanın önemi, önsoğutmanın oranı ve önsoğutma yöntemleri açıklanmıştır.

ABSTRACT: Pre-cooling is the rapid removal of field heat of the grapes until the temperature of the grapes is reduced to the optimum stage or handling temperature. The most important reason to cool the grapes promptly is to minimize water loss. This is strictly a physical fator related to the evaporative potential of the surrounding air.

In this article, importance of the pre-cooling of table grapes, pre-cooling rate and pre-cooling methods used in table grapes are given.

INTRODUCTION

The usual harvest temperatures of table grapes are for rapid transpiration and for the development of decay-causing fungi. The loss of water is more damaging to the grape quality. WINKLER et. Al. (1974) indicated the benefits of pre-cooling in the general rule that, within the limits at which fresh grapes are usally handled, a reduction in temperature of 9.5°C halves the rate of respiration and doubles the keeping period. A fruit temperature below 4.4°C greatly retards the development of all fungi and prohibits the growth of the same (SALUNKHE and DESAI, 1984). Although precooling was intiated by Stubenrauch and Dennis (1910), due to its time and cost factors, it did not become popular in grape transportation and storage until the early "1930"s. In 1932, the railroads altered tariffs permitting grapes to be shipped with modified icing in transit. This removed the economic barrier to pre-cooling and resulted in discovery of numerous refrigeration systems and methods of handling air for cooling (WINKLER et. al. 1974).

The rapid reduction of temperature has three important advantages First, the lower temperature reduces the rate of respiration drastically. For instance, respiration rate at 0°C ise 15 times as slow as it is at 25°C. Respiration rate is inversely proportional to the longevity of the product, thus the more rapid the rate of respiration, the shorter the storage life of the grapes. Second, germination of spores and development of fungi are also greatly influenced by temperature. Many spores of fungi do not germinate at temperatures near zero and others only develop very slowly at such low temperatures. Third, loss of moisture from grapes results in flabby berries and desiccated and brown stems. Loss of moisture from grapes and other biological materials is largely dependent on the difference between the immediate water vapour pressure around the grape berry or product and that of the atmosphere in which the product is stored (GINSBURG and TRUTER, 1976).

The most important reason to cool the grapes promptly is to minimize water loss. This is strictly a physical factor related to the evaporative potential of the surrounding air. It may be expressed directly as vapour pressure deficit (VPD), a term indicating the combined influence of temperature and relative humidity, and is the factor related directly to the rate of water loss from the fruit.

The equation may to expressed as follows:

$$VPD = VP \times (100 - RH)/100$$

Where: VPD = Vapour pressure deficit (mm or inches of Hg)

VP = Vapour pressure of water at a given temperature (mm or inches of Hg)

RH = relative humidity (%)

It is apparent from the above equation that the VPD increases as the VP increases which would occur with a rise of temperature of the grapes, since VP is related directly to temperature of water and the juice of the berries behaves like water. Further, the VPD will increase as the RH is lowered. It is to be expected then that the VPD would be especially high during the typically hot, dry conditions that prevail during harvest of table grapes. Reducing the temperature of this hot harvested fruit promptly and rapidly will therefore drastically reduce the amount of water-loss (NELSON, 1977).

There are at least three symptoms of water loss from grapes. First to appear are shrivelled stems that usually become brittle and break easily when handled. With grapes, unlike most other fruits, the stems serve as a handle to move the fruit. When this handle is broken, the fruit is fruit is lost for all practical purposes, even though the shattered berries themselves still look and taste good. The detached fruit is often referred to as "shatter" or "dry drop". Such losses can be very considerable.

Figure 1 shows how rapidly the stems of harvested grapes can dry, especially if temperatures are high. NELSON (1977) stated that the rate of drying is not only related to temperature but also the rate increases logarithmically. For example, the increase is much greater from 26.6-32.2°C (80-90°F) than from 21.1 (70°F) to 26.6°C (80°F) and greatest from 32.2 - 37.7°C (90-100°F).

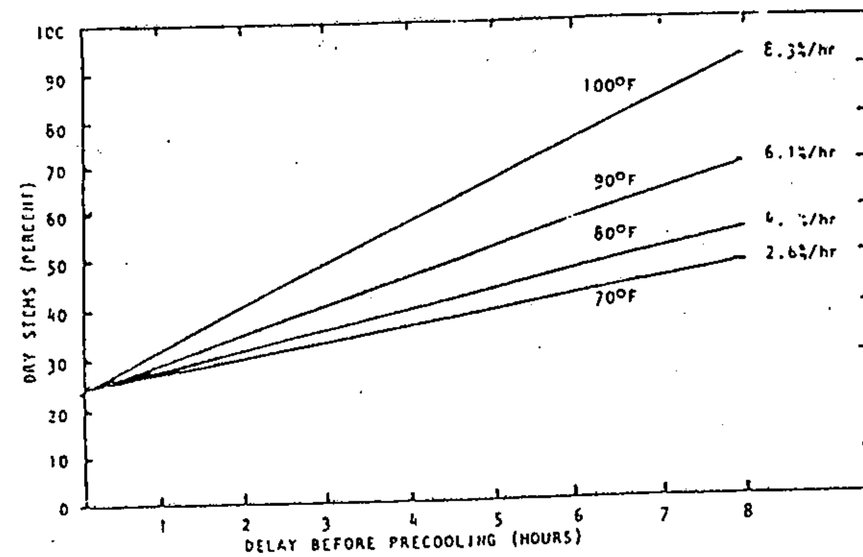

Figure 1. Effect of four different temperatures from harvest to pre-cooling on the percentage of dry stems of grapes

Stems usually turn brown when they dry. Such stems detract seriously from the appearance of the grapes. The brown stem syndrome follows closely that for dry stems and shows the same response to temperature (Figure 2). In fact, it appears that the rate of stem browning increases more rapidly with temperature than does the rate of stem drying. From 21.1-37.7°C (70-100°F) there was about a three-fold increase in stem drying at eight hours whereas the rate for stem browning was over four-fold.

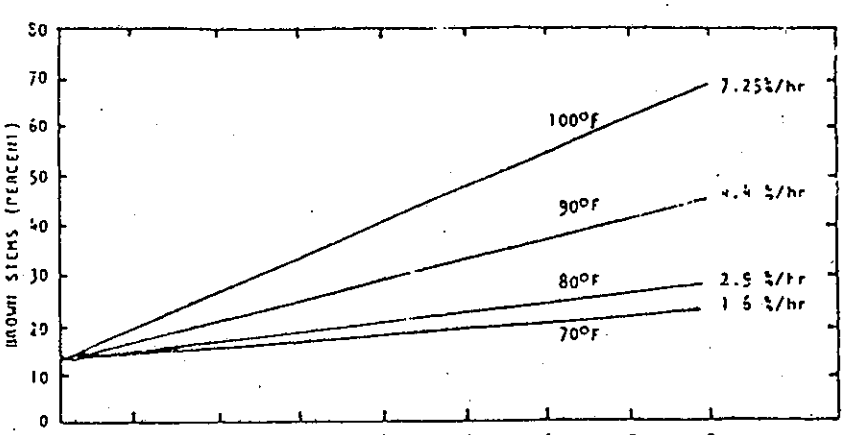

Figure 2. Effect of four different temperatures from harvest to pre-cooling on the percentage of brown stems of grapes

Grape berries do not show symptoms of water loss until the damage is quite evident on stems. However, at about 3% loss in weight the berries start to appear dull as the taut condition of the skin slackens. At 4-5% loss the berries feel definitely soft and above a 5 % loss in weight fine wrinkles start to appear radiating out from the pedicel. Market quality is significantly impaired when the berries feel soft, the berries border on being unacceptable when they show distinct wrinkles. As in the case of the stems, the rate that berry softness appears in related directly to temperature before pre-cooling (Figure 3). The lot of grapes held 8 hours at 37.7°C (100°F) with 75 % of the berries rated "soft" had lost slightly over 3% of the initial weight, while the lot held at 21.1°C (70°C) had lost only 0.5 %.

Therefore, there is a direct relation between weight loss and desiccation symptoms described.

Briefly pre-cooling is the reduction of product temperature at the time of arrival at the time of arrival at the cold store to the optimum low temperature at which the product must be cold stored. In other words pre-cooling is the rapid removal of field heat of the grapes until the temperature of the grapes is reduced to the optimum storage or handling temperature (NELSON, 1977; GINSBURG et. al. 1978).

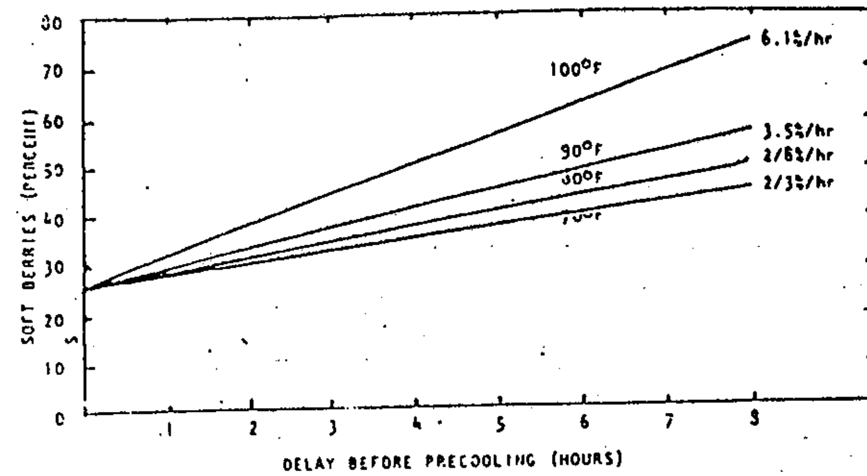

Figure 3. **Effect of four different temperatures from harvest to pre-cooling on the percentage of soft berries of grapes**

The economically feasible and technically practical methods such as "room pre-cooling" and "forced-air cooling are now more commonly employed (SALUNKHE and DESAI, 1984).

Room Precooling:

Most of the table grape cold-storage plants have a number of rooms of small size-holding one thousand to several thousand packed lugs. These rooms have more refrigeration capacity and greater air movement then the regular storage rooms. The small size is desirable in order that the rooms may be filled rapidly and that the extra refrigeration and air volume may speed the cooling. As soon as the grapes are moved into one of these rooms, the cooling machinery is turned on and kept going until the centre lug the last pallet of grapes to be moved in is pre-cooled to the desired temperature (4.4°C).

The cooling capacity of each of these rooms should be sufficient to remove 4.4°C of heat from a full load in twenty-four hours. This requires blowers' capable of moving 6.000 to 8.000; cubic feet of air per minute per 1000 lugs of grapes. The flow of the air to all pasts of the room must be uniform to ensure even cooling. This is also named "parallel flow cooling (WINKLER et al 1974). In the case of parallel flow, the cold air flows along the sides of the containers of grapes. Cooling by this way is appreciably faster than that obtained in a conventional cold room, but not as fast as in well equipped forced-air pre-cooling rooms (SALUNKHE and DESAI, 1984; WINKLER et. al. 1974).

In the case of Room pre-cooling, refrigerated blower coils are suspended from the ceiling (Fig 4). Standard blowers which generally have a throw of 10 m are used for small to medium-sized rooms. The cold air travels along this plenum created by the stow, up to end of the room, where the cold air drops to the floor level of the room i.e., in the space generally 60 mm in width left at the end of the room. This cold air is then drawn past the stacked fruit and some of it passes though the containers. It finally reaches the air return, and is then drawn over the cooling coils again. It is important to stack the fruit so as to ensure an even air flow rate through to stack. Successful room pre-cooling calls for air velocity through the stacks of 60 to 120 metres Per minute. The better the ventilation slots in the containers, the more effective the cooling (GINSBURG and TRUTER, 1976).

Another system is false ceiling system which is a sophisticated room cooling system (Fig 5). A non-insulated ceiling which may be of any impervious material provided it will not taint fruit, is erected just below the blower coils.

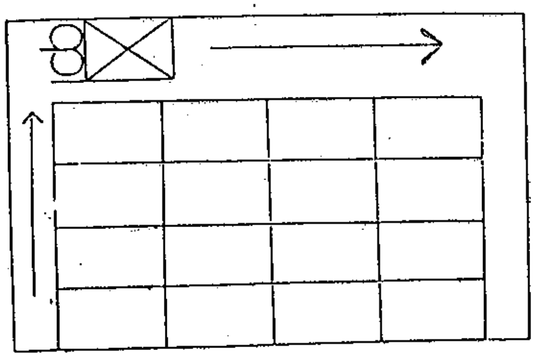

Figure 4. Room cooling system

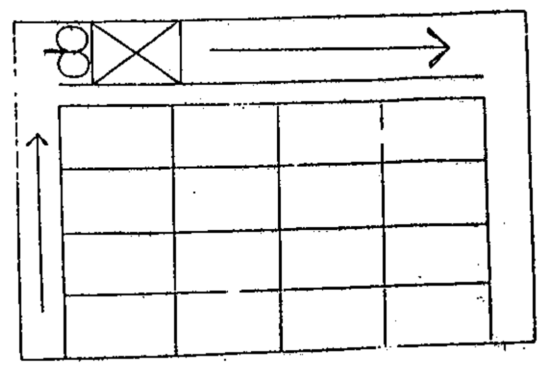

Figure 5. False ceiling system

This system should end one to two metres from the end of the store. This type of design always ensures a positive air flow pattern, which is not dependent on the stack creating the air plenum between ceiling and top of stacks. It is also a guarantee that stacks will not be build up to a height which will block air movement.

Pre-cooling by means of room cooling calls for an open type of stow, so that cooling air can come in to contact with as many faces of the container as possible.

It has the advantage that Pre-cooling and storage takes in the same room, and that, restacking is not necessary. This advantage however does not compensate for the slow cooling rate (GINSBURG and TRUTER, 1976).

Forced - Air Pre-cooling:

Forced-air cooling is both a rapid and safe method for removal of field heat from grapes. Guillov (1960), designed a cooler that forces the cold air through the packed lugs by creating a pressure differential of 0.1 to 1.0 inch of water pressure (GINSBURG et. al. 1978; WINKLER et. al. 1974). The principle of forced-air cooling is shown in figure 6.

It was stated that with the load of fruit as shown in figure 6, grapes can be cooled to

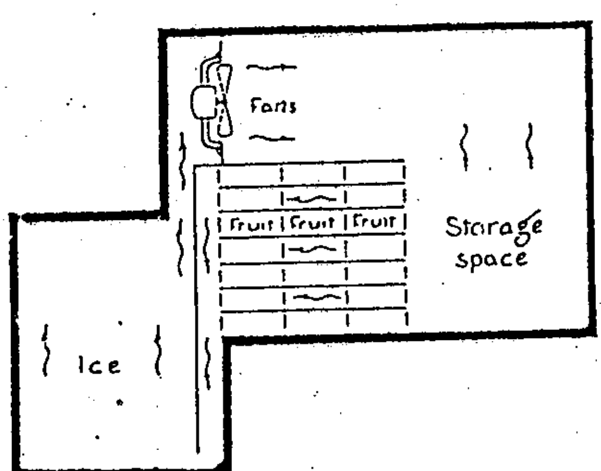

Figure 6. Principle of forced-air cooling

4.4°C± in two hours, whereas the minimum time for conventional pre-cooling is approximately 18 to 24 hours (Fig 7) (WİNKLER et. al. 1974).

Conventional rooms can be converted to this system with varying degrees of modification. Although, a cooler made to take maximum advantage of the principle of differential pressure across the pallets is able to reduce the precooling period to impressively short periods. Any type of cold heat exchange surface could be substituted where "ice" appears in the figure, as long as there is sufficient capacity. It must be remembered that forced air coolers must remove just as much heat from the produces as conventional coolers, since this system removes the heat in a much shorter period of time the refrigeration capacity must be correspondingly higher (NELSON, 1977; WINKLER et. al. 1974).

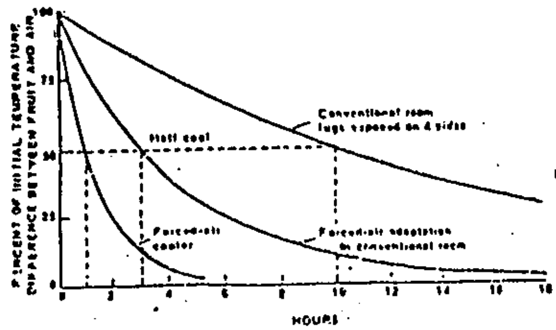

Figure 7. Comparative rates of cooling grapes by different methods average fruit pulp temperature in lidmed lugs

NELSON (1977) also stated that schedules usually become critical in a forced-air facility owing to the rapid turnover as warm fruit is placed "on line" the pre-cooled fruit removed. Consequently it is often very helpful to be able to predict when a given lot of fruit will be cooled adequately and removed for storage or shipment. Useful for this purpose is the half-cooling concept as a basis of calculation (Fig 8).

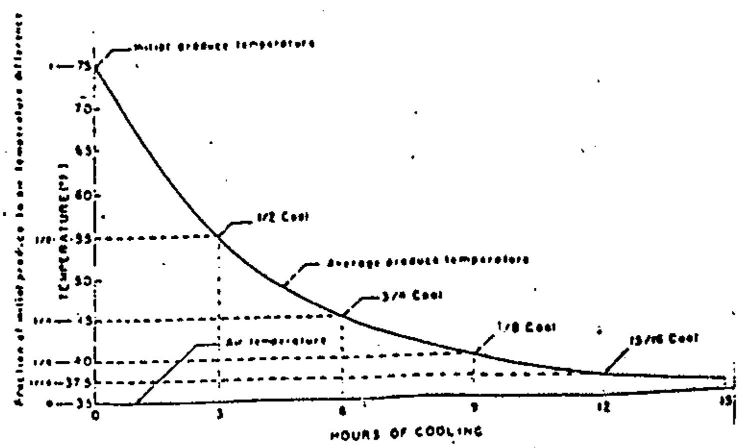

Figure 8. Cooling curve needed to achieve seveneights cooling in nine hours

Pressure cooling

The most effective method of pre-cooling when using air as the cooling medium is pressure cooling. In the case of pressure on opposite sides of stacks of grapes packed in suitably vented containers. The difference in air pressure results in the cold air in the cold store being sucked through the containers and over the grapes (Fig 9).

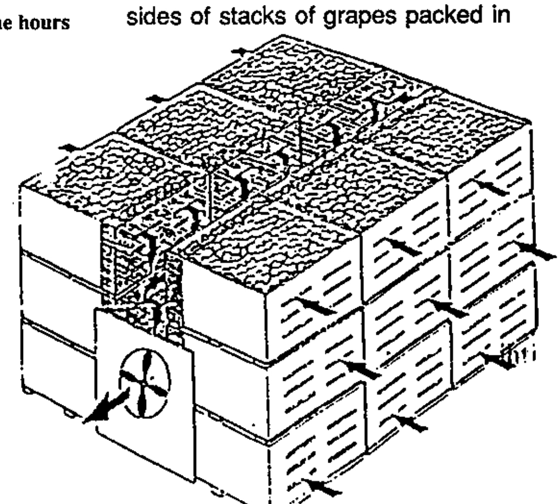

Figure 9. Pressure cooler

Rate of Pre cooling

The rate of pre-cooling is dependent on the following three factors:

1. Close contact between the cooling medium and product.

2. The temperature difference between the cooling medium and product.

3. The velocity of the cooling medium over and product.

Accessibility of the grapes to be cooling medium is influenced by the type of container and any liners, wraps, or filler material and the arrangement of the containers in the cooling chamber.

The greater the difference in temperature between the grapes and the cooling medium, the more rapid is the cooling. The temperature, of course, must not be low enough to freeze the grapes. RICHARDSON et. al. (1977) found when packed lugs were "parallel flow" cooled, the down stream fruit cooled approximately 35 percent faster with cross channels and 45 percent faster when he layers were separated by sparcers (WINKLER et. al. 1974).

For effective and economical cooling as well as rapid, high velocity of the cooling medium is needed. High velocity of the air would remove excessive moisture from the grapes, but such is not the case. The more rapidly the temperature of the grapes can be lowered to the temperature of the cooling medium, the less moisture will be lost.

The function, types and the properties of the pre-cooling for table grapes is explained above, under light of all these explanations, the importance of the pre-cooling can be summarized as follows;

1. Pre-cooling so as so most effective, should be performed as soon after harvesting as possible.

2. Pre-cooling is required to lower the field temperature of grapes to the optimum storage temperature. This therefore not only reduces the loss of weight but also fungal grovth rate during storage.

3. Once the temperature is reduced, it should not be raised temporarily, because it will result in condensation of the water forming on grapes which creates favourable conditions which encourage fungal growth.

4. For pre-cooling so as to have its greatest benefit the initial grape quality must be high. Bunches should not be straggly, should be limited to a minimum.

5. The best method for the rapid pre-cooling of grapes is performed by means of forced-air cooling. As it is mentioned before, this ystem is dependent on drawing and a low pressure area on the different faces of the stack being cooled.

The use of a moisture-proof pack of grapes which would maintain a very high relative humidity within the pack, together with a fumigant system that would check fungal rot development could be as effective as pre-cooling in the production area. Such system is at present being investigated in the U.S.A. then several countries such as France, South Africa, Chile have developed such kind of grape guard pads. Recently. Söylemezoğlu developed slow release SO_2 generator which is capable of storing Müşküle cvs. at 0±1°C, temperature conditions for 2 1/2 months (SÖYLEMEZOĞLU, 1988, 1993).

KAYNAKLAR

GINSBURG, L. and TRUTER, A.B., 1976. Cold Stores For Table Grapes. The Deciduous Fruit Grower. Part. 9, Vol. 26, pp. 360-371.

GINSBURG, L., COMBRINK, J.C. and TRUTER, A.B., 1978. Long and Short Term Storage of Table Grapes. International Journal of Refrigeration. Vol. 1, No. 3.

NELSON, K.E., 1977. Pre-cooling-It8s significance to the Market Quality of Table Grapes. Refrigeration Science and Technology. Vol. 39, Paris.

SALUNKHE, D.K. and DESAI, B.B., 1984. Post-harvest Biotechnology of Fruits, CRC Press, Inc. Vol. 1, USA. 168 pp.

SÖYLEMEZOĞLU, G., 1988. Üzümün Soğukta Muhafazasında Fümigasyon Örtüsünün Etkinliği Üzerinde Bir Araştırma. Ankara Üniversitesi Fen Bilimleri Enstitüsü (Basılmamış, Yüksek Lisans Tezi). 108 s.

SÖYLEMEZOĞLU, G., 1993. Türkiye'de Üretilen Çeşitli Kağıt-Plastik Materyal Kombinasyonlarından Geliştirilen Fümigasyon Örtülerinin Sofralık Üzümlerinin Muhafazasındaki Etkinliği Üzerinde Bir Araştırma. Ankara Üniversitesi Fen Bilimleri Enstitüsü (Basılmamış, Doktora Tezi). 135 s.

WINKLER, A.J., COOK, J. A., KLIEWER, W. M. and LIDER, L. A., 1974. General Viticulture. University of California Press. Berkeley, Los Angeles, London.