

## RESEARCH NOTE

# The Influence of Storage Duration and Elevation of Storage Temperature on the Development of Berry Split and Berry Abscission in *Vitis vinifera* L. cv. Thompson Seedless Table Grapes

D.A. Burger<sup>1\*</sup>, G. Jacobs<sup>2</sup>, M. Huysamer<sup>2</sup> and M.A. Taylor<sup>1</sup>

(1) Experico, P.O. Box 7441, 7599 Stellenbosch, South Africa

(2) Department of Horticultural Science, Stellenbosch University, Private Bag X1, 7602 Matieland (Stellenbosch), South Africa

Submitted for publication: September 2003

Accepted for publication: September 2005

Key words: *Vitis vinifera*, Thompson Seedless, berry split, berry abscission, storage duration, storage temperature

**Thompson Seedless grapes, packed in non-perforated low density polyethylene bags, were cold stored at -0.5°C and RH 83% for 0, 1, 2, 4 and 8 weeks. After storage at -0.5°C for these periods, the grapes were stored for another 2 or 5 days at -0.5°C, or the grapes were transferred and stored at 10°C and RH 88% for 2 or 5 days. The polyliners were kept closed during the different storage periods. Fruit quality examinations were conducted after the specified periods at -0.5°C, and after each additional 2 and 5 days at both temperatures. Berry split increased with prolonged storage at -0.5°C. A linear function ( $y = 0.58x - 1.14$ ;  $R^2 = 0.97$ ) described this increase in berry split over 61 days storage at -0.5°C. Transferring the grapes from -0.5°C to 10°C resulted in a further increase in berry split. Grapes stored for 0, 1, 2 and 4 weeks at -0.5°C followed by 5 days at 10°C, showed a significant increase in berry split, compared with grapes stored only at -0.5°C for the same period. Although significant differences in berry abscission occurred, no definite trend was observed that could be ascribed to storage period at -0.5°C or to an elevation in storage temperature from -0.5°C to 10°C.**

Grapes (*Vitis vinifera* L.) are a highly perishable commodity and their market life is a function of time and temperature, with the degree of deterioration related directly to the length of exposure to higher temperatures, regardless of when exposure occurs (Nelson, 1979).

The period between harvest and marketing of table grapes can be divided into different phases, and each phase can play a vital role regarding the maintenance of fruit quality. The duration and temperature of the phase between harvest and packing, as well as between packing and the onset of forced-air cooling (FAC), can determine the difference between top-quality and unacceptable quality fruit (Combrink *et al.*, 1975; László & Saayman, 1992). After the onset of FAC, the duration of the cooling process can also have a significant influence on the market quality of the grapes (Ginsburg & Combrink, 1972). In South Africa, grapes packed in non-perforated low-density polyethylene (LDPE) bags are subjected to FAC that reduces grape temperature to -0.5°C within a maximum of 72 hours. The grapes are mainly cooled by means of conduction, since the cold air forced through the cartons on pallets is prevented from direct contact with the grapes, since the bags act as a barrier between the cold air and the grapes (Ginsburg *et al.*, 1978). After FAC has lowered the product temperature to -0.5°C, the cold storage phase during transport and the accumulation period is also extremely important in determining post-storage quality. This is mainly due to the length of the period, and the risk of temperature fluctuations that may occur.

Following FAC, fruit can be accumulated for 3 to 12 days at -0.5°C before being loaded onto ships. Sea export of South African table grapes to Middle East markets takes ca. 14 days, ca. 16 days to European markets, and ca. 22 days to the Far East and USA. In addition to these periods, South African grapes can be held for a further 7 to 18 days overseas before being sold to the retailer, depending on market conditions. Extended periods of sea freight, and the potential requirement to roll stocks until there is sufficient demand to ensure profitable returns, has resulted in a pressing need to increase the storage life of table grapes under refrigerated conditions, so that fruit can be marketed for longer periods.

Table grape cultivars have different cold storage potentials, which can vary from 5 to 10 weeks (Ginsburg, 1965). A cultivar's storage potential is determined by its susceptibility to quality defects during cold storage. These defects would include physiological disorders, fruit rot and desiccation. Decay excluded, berry split and berry abscission are the primary disorders which shorten the storage potential of Thompson Seedless table grapes.

This study was conducted to determine the effects of cold storage duration at -0.5°C, and an elevation in temperature to 10°C after various periods at low temperature, on the development of berry split and berry abscission in Thompson Seedless table grapes.

### MATERIALS AND METHODS

The study was conducted in 1998 in a Thompson Seedless vineyard in the De Doorns area (lat. 33°30'S, long. 19°45'E) in the

\*Corresponding author: E-mail address: dirk@experico.co.za

Western Cape, South Africa. The vineyard was planted in 1974, on Richter 99 rootstock. The vines were trained onto a slanting trellis system with a 1.8 x 2.7 m spacing, and irrigated by sprinkler irrigation. The recommended gibberellic acid sprays for Thompson Seedless were applied (Wolf *et al.*, 1991). The vines were girdled when the berries were between 4 and 6 mm in diameter. Thompson Seedless grapes were harvested with total soluble solids (TSS) of 16.9°Brix and titratable acid levels (TA) of 0.59%. The grapes were harvested between 6 and 7 a.m., when the average pulp temperature of the grape berries was 16.6°C. The grapes were packed in 4.5-kg closed-top corrugated fibre board cartons, with individual bunches in plastic carrybags, and the entire carton content enclosed in a 20- $\mu$ m non-perforated LDPE liner. A Uvasys® sulphur dioxide (SO<sub>2</sub>) generator sheet (Grapetek, South Africa) was enclosed in each of the polyliners, positioned on top of the grapes, to control decay. The LDPE liner containing the grapes and the SO<sub>2</sub> sheet was folded, closed with gum tape, and placed under passive cooling within 3 hours after packing. Samples were cold stored at -0.5°C and a relative humidity (RH) of 83% for 0, 1, 2, 4 and 8 weeks. After storage at -0.5°C, the grapes were either stored for another 2 or 5 days at -0.5°C, or they were transferred to and stored at 10°C and RH 88% for 2 or 5 days. The LDPE bags were kept closed during the different storage periods.

For measurement of TSS and TA at harvest, 50 randomly selected berries from five randomly selected grape bunches were used. The berries were juiced in a liquidiser and filtered. The percentage soluble solids of the filtrate, expressed as °Brix, was measured using a bench top Palette PR100 digital refractometer with automated temperature compensation (Atago Co., Japan). TA was determined by titrating a 10-g aliquot of juice with 0.1 N NaOH to an end-point pH 7, using a 665 Dosimat auto-titrator (Metrohm Co., Switzerland). Pulp and ambient temperatures were recorded with a probe connected to a Kane-May 22 digital thermometer (Comark Ltd., U.K.), and a swirling hygrometer

was used to determine the wet and dry bulb temperatures. Relative humidity was then determined from a psychrometric chart (CSIR, 1981).

Fruit quality was assessed at ambient temperature (ca. 24°C), after 0, 1, 2, 4 and 8 weeks at -0.5°C, as well as after the additional 2 or 5 days at -0.5°C or 10°C. Grapes were examined for the quality defects berry split and berry abscission. Berry split was recorded when any split, whether restricted to the epidermis or deeper into the mesocarp, was visible. Artefactual berry split due to external stresses from manual or mechanical sources, e.g. as caused by excessive pressure on the fruit during lidding, was not taken into account. For berry abscission, all berries with “dry” scars remaining in the carry bag on removal of the bunch were recorded. Berries that were torn loose due to improper handling or berry split around the pedicel end were not recorded. All of the grapes in each carton were examined. The incidence of each defect was expressed as a percentage of the total grape mass per carton.

The experimental design was completely randomised. Each treatment was replicated five times, with one carton constituting a single replication. Data were subjected to an analysis of variance using the General Linear Means procedure of the Statistical Analysis System (SAS Institute Inc., 1996).

## RESULTS AND DISCUSSION

The incidence of berry split increased with prolonged storage at -0.5°C (Fig. 1) and this increase was often significant. A linear function ( $y = 0.58x - 1.14$ ) with an R<sup>2</sup>-value of 0.97 described this increase in berry split over eight weeks of storage at -0.5°C. During the first week of storage at -0.5°C, the incidence of berry split was very low. A rapid increase in berry split commenced from the second week of storage at -0.5°C. After 8 weeks of storage at -0.5°C (day 56), no further increase in berry split occurred. Transferring grapes from -0.5 to 10°C consistently resulted in a rapid increase in berry split. Even after only 2 days of storage at 10°C, an increase in berry split relative to levels at -0.5°C was

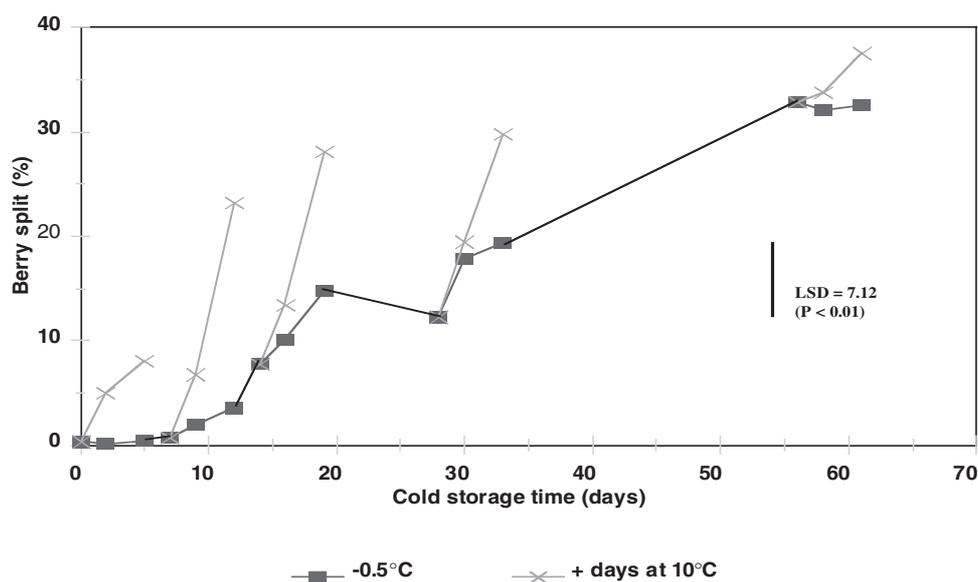


FIGURE 1

Effect of storage time at -0.5°C, and an elevation in temperature to 10°C, after 0, 1, 2, 4 and 8 weeks, on the development of berry split in Thompson Seedless table grapes.

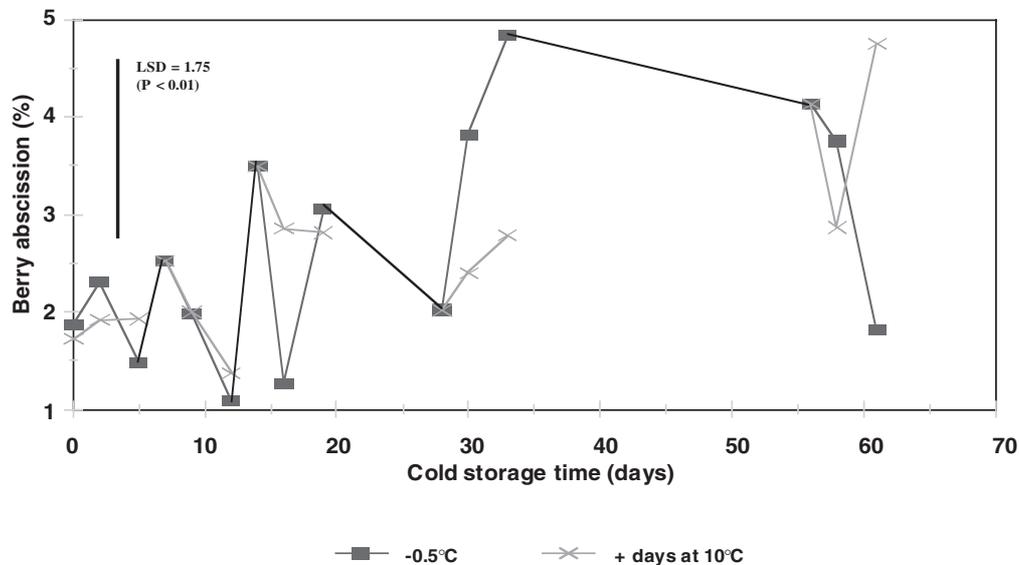


FIGURE 2

Effect of storage time at  $-0.5^{\circ}\text{C}$ , and an elevation in temperature to  $10^{\circ}\text{C}$ , after 0, 1, 4 and 8 weeks, on the development of berry abscission in Thompson Seedless table grapes.

evident at each transfer. Grapes stored for 0, 1, 2 and 4 weeks at  $-0.5^{\circ}\text{C}$  followed by 5 days at  $10^{\circ}\text{C}$ , showed a significant increase in berry split, compared with grapes stored only at  $-0.5^{\circ}\text{C}$  for the same period. After 8 weeks there was no significant difference in berry split between grapes stored only at  $-0.5^{\circ}\text{C}$ , and grapes stored for 8 weeks at  $-0.5^{\circ}\text{C}$ , followed by 2 or 5 days at  $10^{\circ}\text{C}$ . The levelling off of berry split after 8 weeks at  $-0.5^{\circ}\text{C}$  possibly signifies the stage at which most berries that were prone to split had in fact developed the disorder. This is supported by the fact that transfer of grapes to  $10^{\circ}\text{C}$  after 8 weeks at  $-0.5^{\circ}\text{C}$  did not result in a further significant increase in split, whereas the increase following transfer was significant at all earlier stages.

Although there were sometimes significant differences in the occurrence of loose berries, especially for grapes stored only at  $-0.5^{\circ}\text{C}$ , no definite trend was observed that could be ascribed to storage period at  $-0.5^{\circ}\text{C}$ , or to an elevation in storage temperature from  $-0.5^{\circ}\text{C}$  to  $10^{\circ}\text{C}$  (Fig. 2).

The increase in berry split over time in storage at  $-0.5^{\circ}\text{C}$  was almost linear. A consequence of establishing such a relationship between the incidence of berry split and a quantifiable factor, such as days of storage at  $-0.5^{\circ}\text{C}$ , is the ability to predict the potential incidence of the disorder based on data collected during early storage. This has commercial value, since accurate prediction of berry split can be used to segregate grapes according to berry split risk. To reduce the risk, it will be possible to sell high-risk product first.

## CONCLUSIONS

Two storage related factors have a significant influence on the incidence of berry split in Thompson Seedless grapes during cold stor-

age, viz. the duration of storage at  $-0.5^{\circ}\text{C}$ , as well as an increase in temperature after low temperature storage. Berry split increased almost linearly with prolonged storage at  $-0.5^{\circ}\text{C}$ . An increase in storage temperature from  $-0.5^{\circ}\text{C}$  to  $10^{\circ}\text{C}$  any time during the cold storage period further aggravated the split problem. Consequently, the reduction of berry split in Thompson Seedless table grapes during cold storage requires (a) the shortest possible cold storage period, and (b) good temperature management throughout distribution, from initiation of cooling until the final point of sale.

## LITERATURE CITED

- Combrink, J.C., Ginsburg, L. & Truter, A.B., 1975. Partial cooling of table grapes prior to packing. *Decid. Fruit Grower* 25: 148-152.
- CSIR, 1981. NMERI psychrometric chart. Council for Scientific and Industrial Research, National Mechanical Engineering Research Institute, Pretoria.
- Ginsburg, L., 1965. Recommended storage temperatures, percentage relative humidities and storage life for fruit and vegetables. *Decid. Fruit Grower* 15: 80-86.
- Ginsburg, L. & Combrink, J.C., 1972. The importance of pre-cooling of table grapes. *Decid. Fruit Grower* 22: 60-64.
- Ginsburg, L., Combrink, J.C. & Truter, A.B., 1978. Long and short term storage of table grapes. *Int. J. Refrigeration* 1: 137-141.
- László, J.C. & Saayman, D., 1992. Cooling trials with Sultanina grapes. *Decid. Fruit Grower* 42: 145-152.
- Nelson, K.E., 1979. Harvesting and handling of California table grapes for market. University of California, Publication 4095: 38-49.
- SAS Institute Inc., 1996. SAS user's guide: statistics, Version 5 Edition. SAS Institute, Cary, N.C.
- Wolf, E.E.H., Van der Merwe, G.G. & Orth, C.H.F., 1991. Optimal gibberellic acid concentrations for the production of high quality Sultanina in the Orange River area. *Decid. Fruit Grower* 41: 337-340.