Influence of harvest maturity on quality of cold stored *Vitis vinifera* L. cv. ‘Thompson Seedless’ and ‘Red Globe’ table grapes, with special reference to berry split

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Effect of harvest maturity on quality of ‘Thompson Seedless’ and ‘Red Globe’ table grapes after cold storage at -0.5°C and a subsequent shelf life was investigated. Berry split decreased significantly for grapes harvested at more advanced maturities. By harvesting ‘Thompson Seedless’ grapes at total soluble solids (TSS) 20 °Brix and titratable acids (TA) 0.4%, instead of TSS 17.3 °Brix and lower, and TA 0.5% and higher, the incidence of post-storage berry split was reduced by ca. 87%. By harvesting ‘Red Globe’ grapes at TSS 16.1 °Brix, instead of TSS 15.0 °Brix and lower, berry split was reduced by ca. 78%. However, grapes harvested too mature showed an increase in stem desiccation and SO₂ damage around the pedicel end of berries for both cultivars. ‘Thompson Seedless’ grapes harvested too mature also showed an increase in Botrytis decay. To ensure acceptable quality of cold stored ‘Thompson Seedless’ and ‘Red Globe’ table grapes, it is imperative to harvest as soon as possible after horticultural maturity has been reached.

Key words: Botrytis decay, SO₂ damage, stem desiccation

Introduction

One of the most widespread physiological disorders that limits the production and marketing of soft, fleshy and blemish-free fruit is cracking of the skin and splitting of the underlying flesh. Fruit species in which this is a significant horticultural problem are cherries (Christensen, 1975), grapes (Meynhardt, 1964a), tomatoes (Reynard, 1960), citrus (García-Luis, Duarte, Porras, Garcia-Lidon & Guardiola, 1994), prunes (Mrozek & Faust, 1976) and apples (Faust & Shear, 1972). Cracking and splitting also occurs extensively in grain crops, e.g. rice (Lague & Jenkins, 1991) and in vegetable crops such as sweet potatoes (Lutz, Deonier & Walters, 1949) and carrots (McCarr, 1993).

Cracking and splitting of grape berries during cold storage is a major problem in South African table grape production. The severity of damage varies with the cultivar. Cultivars ‘Thompson Seedless’, ‘Sunred Seedless’, ‘Red Globe’, ‘Queen of the Vineyard’ and ‘Flame Seedless’ are especially susceptible. According to Capespan, a company marketing South African produced grapes on export markets, packed cartons affected by this disorder during the 1999 season were approximately 20.8% (T. Olivier, Pers. Comm. Capespan (Pty) Ltd, Bellville, South Africa). The total export value of cartons affected and at risk from splitting was estimated to be over R11.4 million. Inferior grape quality owing to berry cracking and splitting usually results in a considerable decline in consumer confidence and a corresponding drop in demand for, and price of the product. This can lead to even further financial losses on highly competitive markets overseas.

In fruit research, contradictory literature exists regarding the influence of harvest maturity on the incidence of fruit splitting. A study on berry splitting susceptibility concluded that osmotic concentration of fruit soluble solids, and therefore berry maturity, is a major factor controlling water absorption through the berry skin and, hence, berry split (Meynhardt, 1964b). In contrast, Tucker (1934), Kertesz and Nebel (1935), and Andersen and Richardson (1982) found no or very weak correlations between sugar content or osmotic potential of sweet cherry fruit and its tendency to split. In an attempt to clarify discrepancies concerning the effect of harvest maturity on berry split in ‘Thompson Seedless’ and ‘Red Globe’ table grapes, this study determined the effect of harvest maturity on overall quality.

Material and methods

This experiment was carried out in two vineyards in the Western Cape, viz., in a ‘Thompson Seedless’ block in the Saron area in 2000, and in a ‘Red Globe’ block in the Riebeek Kasteel area in 2003. The ‘Thompson Seedless’ vineyard was planted in 1989 on ‘Richter 99’ rootstock, with a 2 × 3 m spacing and trained onto a double gable system. The ‘Red Globe’ vineyard was planted in 1999 on ‘Ramsey’ rootstock, at a spacing of 1.8 × 3 m, and trained onto a slanting trellis system. Both vineyards were irrigated by a drip irrigation system. Standard cultural practices were followed regarding irrigation, fertilization, bunch preparation, pest and disease control and foliage management.

Grapes were harvested weekly at different stages of maturity once horticultural maturity, as defined by Watada, Herner, Kader, Romani and Staby (1984), was attained. Samples of 100 berries per replicate were randomly collected at each harvest maturity for measurements of total soluble solids (TSS) and titratable acids (TA). Berries were juiced in a liquidizer and filtered. 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). Titratable acidity, expressed as percentage tartaric acid, was determined by titrating a 10 g aliquot of juice with 0.1 N NaOH to an endpoint pH 7, using a 665 Dosimat auto-titrator (Metrohm Co., Switzerland).
Grapes sampled on each harvest date were packed in 20 µm thick non-perforated, low-density polyethylene liners inside 4.5 kg closed-top cartons. A UVasys® SO2 sheet was enclosed in each of the polyethylene liners on top of the grapes for postharvest fungal control. For ‘Red Globe’ grapes, a moisture absorbing paper sheet was placed between the grapes and the SO2 sheet. Polyethylene bags containing grapes and the SO2 sheet were folded, sealed with gum tape and placed in cold storage within 3 hours after packing. ‘Thompson Seedless’ grapes were cold stored for 5 weeks at -0.5°C and 7 days at 10°C, while ‘Red Globe’ grapes were stored for 8 weeks at -0.5°C and 4 days at 7.5°C. Fruit quality was assessed at ambient temperature (=24°C) after this storage period. The polyethylene liners were kept closed during the shelf life period. Grape quality was assessed in terms of berry split, berry abscission, stem condition and Botrytis decay. ‘Red Globe’ grapes were also examined for SO2 damage around the pedicel end as well as on the surface of the berries. For ‘Thompson Seedless’ grapes, all the grape bunches per carton were examined. For ‘Red Globe’ grapes, three randomly selected bunches per carton were examined. The incidence of Botrytis decay, berry split, berry abscission and SO2 damage was expressed as a percentage of total sample mass. Stem condition, that includes the condition of the pedicels, primary and secondary rachis, was rated on a five-point scale, where 1 = fresh, green stems and 5 = dry, brown stems.

A randomised complete block design was used, with each block replicated six times. Each individual plot consisted of four vines. One-way ANOVA was used to analyse the data.

Results and discussion

Grapes harvested at different dates showed significant differences in TSS and TA for both ‘Thompson Seedless’ (Table 1) and ‘Red Globe’ (Table 2) grapes. TSS increased and TA decreased with time, indicating an advance in maturity.

After ‘Thompson Seedless’ grapes had been stored for 5 weeks at -0.5°C followed by 1 week at 10°C, grapes harvested at different stages of maturity showed significant differences in berry split, pedicel SO2 damage, stem desiccation and Botrytis decay (Table 3). No significant difference in berry abscission occurred between grapes harvested at the different dates. No surface SO2 damage was detected in any treatment (data not shown).

After 8 weeks at -0.5°C and 4 days at 7.5°C, ‘Red Globe’ grapes harvested on the third harvest date showed a significant decrease in berry split, whereas stem desiccation and pedicel SO2 damage increased significantly compared to grapes harvested on the first or second harvest date (Table 4). No significant differences in surface SO2 damage and Botrytis decay were observed on grapes harvested at the different stages of maturity.

The incidence of berry split decreased significantly for grapes harvested from the third harvest date (Tables 3 and 4). Two maturity related fruit factors could possibly influence the grape berry susceptibility to split, viz. osmotic concentration of the fruit soluble solids, and properties of the berry skin.

Since water absorption into plant cells is predominantly an osmotically driven process and post-harvest fruit splitting seems to be related to water absorption (Verner & Blodgett, 1931), many researchers have attempted to correlate differences in splitting with variations in osmotic concentration of the fruit juice. Several studies on cracking susceptibility in sweet cherries (Prunus avium L.) concluded that the osmotic concentration of fruit soluble solids is a major factor controlling water absorption and cracking (Sawada, 1931; Verner & Blodgett, 1931; Bullock, 1952). Cracking of sweet cherries is due to an osmotic absorption of water that correlates with the degree of maturity (Sawada, 1931). Similarly, with apples (Malus domestica Borkh.) and prunes (P. domestica Ehrh.), splitting potential increased with advanced maturity (Fisher, 1937; Mrozek & Burkhardt, 1973). In contrast, Tucker (1934), Kertesz and Nebel (1935), Zielinski (1964), Chris-

Table 1 Weekly changes in maturity of ‘Thompson Seedless’ table grapes sampled from Saron area in the 2000 season

<table>
<thead>
<tr>
<th>Variables</th>
<th>Harvest date</th>
<th>F prob = 0.012</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS (°Brix)</td>
<td>12/1</td>
<td>18.0a</td>
</tr>
<tr>
<td>TA (%)</td>
<td>0.6a</td>
<td>0.5b</td>
</tr>
</tbody>
</table>

1 Variates in the same row labelled with different letters indicate significant differences according to LSD test.
2 One-way ANOVA table with randomised complete block design.

Table 2 Weekly changes in maturity of ‘Red Globe’ table grapes sampled from Riebeek Kasteel area in the 2003 season

<table>
<thead>
<tr>
<th>Variables</th>
<th>Harvest date</th>
<th>F prob = 0.012</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS (°Brix)</td>
<td>29/1</td>
<td>13.0a</td>
</tr>
<tr>
<td>TA (%)</td>
<td>0.5a</td>
<td>0.3a</td>
</tr>
</tbody>
</table>

1 Variates in the same row labelled with different letters indicate significant differences according to LSD test.
2 One-way ANOVA table with randomised complete block design.

Table 3 Effect of harvest maturity on the quality of ‘Thompson Seedless’ grapes sampled from Saron in 2000, after 5 weeks storage at -0.5°C plus 1 week at 10°C

<table>
<thead>
<tr>
<th>Variables</th>
<th>Harvest date</th>
<th>F prob = 0.012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berry split (%)</td>
<td>12/1</td>
<td>22.4b</td>
</tr>
<tr>
<td>Stem condition</td>
<td>2911</td>
<td>1.0a</td>
</tr>
<tr>
<td>Pedicel SO2 damage (%)</td>
<td>3/2</td>
<td>3.4a</td>
</tr>
<tr>
<td>Berry abscission (%)</td>
<td>10/2</td>
<td>1.2</td>
</tr>
<tr>
<td>Botrytis decay (%)</td>
<td>10°C</td>
<td>0.2a</td>
</tr>
</tbody>
</table>

1 Variates in the same row labelled with different letters indicate significant differences according to LSD test.
2 One-way ANOVA table with randomised complete block design. Not significant (NS), or significant for P < 0.01 (**).
3 Stem condition was ranked from 1 to 5, where 1 = green stems and 5 = dry, brown stems.
stems have a much larger surface area-to-mass ratio than due to a more developed abscission layer in riper fruit. Since grape berries (Ginsburg 1979), stems lose moisture more readily than berries. As a result, water diffuses from the berries to the stems in response to a water potential gradient. As the berries ripen, the abscission layer develops, and this can possibly create an obstruction for water movement from the berries to the stems. Therefore, grapes at advanced ripeness levels are probably more susceptible to stem desiccation.

‘Thompson Seedless’ and ‘Red Globe’ grapes harvested at the most advanced maturity developed significantly higher levels of SO₂ damage around the pedicel end of berries than grapes harvested less mature (Tables 3 and 4). The increase in stem desiccation with increased maturity can possibly explain the increase in pedicel SO₂ damage with increased maturity. Stem desiccation includes desiccation of the pedicel, and this normally results in a weaker attachment of the berry to the pedicel. Consequently, SO₂ gas can more readily penetrate the fruit in this area, resulting in an increase in SO₂ damage at the pedicel end. Although pulp temperature was not measured at the different harvest maturities of ‘Thompson Seedless’ grapes, extremely high ambient temperatures prevailed during the fourth harvest maturity, causing conditions that enhanced SO₂ damage. This could further explain the extremely high level of pedicel SO₂ damage on ‘Thompson Seedless’ grapes harvested at the last maturity.

‘Thompson Seedless’ grapes harvested at the most advanced maturity developed significantly higher levels of Botrytis decay than grapes harvested less mature (Table 3). Natural resistance to Botrytis cinerea infection decreases as grape maturity increases (Jeandet, Bessis & Gautheron, 1991), explaining the significant increase in Botrytis decay for ‘Thompson Seedless’ grapes harvested at the most advanced maturity.

‘Red Globe’ grapes harvested at second harvest date had low levels of berry abscission (0.6%), while grapes from the other two harvest dates showed no berry abscission (Table 4). This is difficult to explain, although it is almost certain not to be maturity related.

Since table grapes are non-climacteric fruit, they do not ripen after harvest (Kanellis & Roubelakis-Angelakis, 1993). Table grapes should therefore only be harvested after they reach acceptability in appearance, flavour and texture. Grapes harvested immature are more susceptible to berry split and have poor eating quality. However, grapes harvested over mature, are more prone to stem desiccation and the development of Botrytis decay and pedicel SO₂ damage. Therefore, to ensure acceptable quality of cold stored table grapes, it is imperative to harvest as soon as possible after the minimum harvest maturity has been reached, and to remain within the acceptable maturity window.

Conclusions

Advanced maturity increased grape resistance to berry split. However, grapes harvested too mature are more prone to stem desiccation and the development of Botrytis decay, as well as to SO₂ damage around the pedicel end. Consequently, to ensure broadly acceptable quality, grapes should be harvested as soon as the minimum requirement in terms of appearance, flavour and texture has been reached. This may, under certain conditions and seasons, increase susceptibility to berry cracking.

<table>
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<tr>
<th>Variables</th>
<th>Harvest date</th>
<th>F prob = 0.05²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berry split (%)</td>
<td>29/1</td>
<td>3/2</td>
</tr>
<tr>
<td>Stem condition³</td>
<td>3.7</td>
<td>4.1</td>
</tr>
<tr>
<td>Surface SO₂ damage (%)</td>
<td>2.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Pedicel SO₂ damage (%)</td>
<td>0.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Berry abscission (%)</td>
<td>1.8</td>
<td>0.6</td>
</tr>
</tbody>
</table>

¹Variates in the same row labelled with different letters indicate significant differences according to LSD test.
²One-way ANOVA table with randomised complete block design. Not significant (NS), or significant for P < 0.05 (*) or P < 0.01 (**).
³Stem condition was ranked from 1 to 5, where 1 = green stems and 5 = dry, brown stems.
References


SAWADA, E., 1931. Studies on the cracking of sweet cherries. Agric. and Hort. 6, 865-892.


