THE POSSIBLE ROLE OF FORCED-AIR COOLING IN BERRY BROWNING DEVELOPMENT OF TABLE GRAPES

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Why investigate forced-air cooling?

Berry browning emerged as a major post-storage quality disorder in the table grape industry, after the turn of the millennium. A programme was initiated by the industry, to identify various parameters which may correlate with the incidence of browning in white table grape cultivars and to determine factors which may predispose these cultivars to berry browning. At the time, the grape industry was in a rapid expansion phase and since many cold storage operators increased their refrigeration capacity or made adjustments to practices for increased throughput, a common perception existed that incorrect cooling practices might be the cause of the berry browning problem. This paper includes results of experiments conducted in 2006 and 2007, to investigate the possible role or influence of forced-air cooling practices on development of berry browning in table grapes. The research was conducted on behalf of SATI and DFPT-Research.

The possible role of delivery-air temperature, end-point temperature and duration of forced-air cooling was studied

The effect of delivery air temperature (DAT), as well as the duration of forced-air cooling (FAC) on external and internal browning of cold stored Regal and Thompson Seedless table grapes was studied. The treatments investigated were DAT's at 3°C, -0.5°C and -2.5°C, applied for 24 h and 72 h. The targeted end-point temperatures were similar to the aforementioned DAT's. The practical difference between the 24 h versus 72 h FAC was that with the 24 h FAC treatment, the forcing of the cold air was discontinued shortly after grape pulp temperature came within 0.5°C of the target end-point temperature, while with the 72 h FAC duration, the forced movement of cold air through the boxes was continued for approximately 48 h after the grape pulp reached the targeted end-point temperature. The 24 h FAC duration treatment therefore represented typical commercial conditions for "uniform" cooling tunnels, while the 72 h FAC treatment represented extended FAC duration. The latter represents commercial situations that are usually not planned, but which may occur as a result of operational situations arising at the refrigeration facility. Grape berry browning development was evaluated on six 4.5 kg industry standard grape box replicates per treatment combination, after 1, 5 and 9 weeks of cold storage at -0.5°C. The incidence of berries exhibiting external browning, including different types of browning such as mottled, net-like, contact and peacock spot browning was recorded. The incidence score was weighted to obtain a severity index, based on the affected area of each individual grape berry : < 25% x 1; 26-50% x 2; 51-75% x 3; > 75% x 4. Similarly, the incidence of berries exhibiting internal browning, including glassy berries and chocolate berries was recorded and weighted. Typical browning symptoms are depicted in Figure 1. More detailed graphical information about different types of grape berry browning can be obtained from the article by Fourie (2008), and is also available from the websites www.dfptresearch.co.za and www.satgi.co.za.

Delivery air temperature in the range -2.5° C to 3° C and forcing of refrigerated air for 24 h or 72 h through the boxes did not influence berry browning development in a consistent manner

Examples of the pooled data depicting the pattern of external (Figure 2) and internal berry browning (Figure 3) development during cold storage of a Regal Seedless grape population are shown. Neither internal nor external browning incidence was increased by increasing the duration of forced-air cooling from 24 h to 72 h (data not shown). External browning increased during the 1 to 5 week storage period (Figure 2). This trend was in agreement with the research of Vial, et al. (2005), who found that grape skin browning reached its highest expression after 3 weeks of cold storage. Internal browning levels increased during cold storage, especially towards 9 weeks of cold storage (Figure 3).

No consistent, repeatable effect of DAT and FAC duration on berry browning incidence was demonstrated in the four experimental populations tested. From these trials incorporating different DAT and FAC durations, eleven data sets were generated. From these, no significant role for DAT in external browning development could be demonstrated in eight of the data sets. The role of FAC duration in external browning was not significant in nine of the data sets. Similarly, the treatment combinations did not influence internal browning significantly in seven of the data sets. Furthermore, although not an objective of this study, the variation in browning incidence between different bunches was often very noticeable, as demonstrated in Figure 4, which shows the remaining healthy berries of two grape bunches, sourced from the same box and therefore subjected to an identical treatment, after all the berries affected by browning had been removed. Therefore, within the range of treatments applied on the experimental populations, it appears unlikely that FAC delivery air-temperature and duration are the primary or dominant causal factors of berry browning in table grapes. Despite the above conclusion, statistical differences in specific populations indicated that FAC conditions may influence the grapes, depending on the inherent quality potential, as follows:

- Internal browning increased dramatically and to significant proportions with the combination of FAC at –2.5° C for 72 h in one Thompson Seedless population. It is suggested that this browning might have been a chilling injury response that became evident after prolonged storage.
- By contrast, in other Regal and Thompson Seedless populations, the "warmer" treatment combinations appeared to be more conducive to internal browning than the "colder" treatment combinations. This contradicted the general perception at the time that "higher" DAT and slower cooling rates are beneficial to reduce browning in sensitive table grape varieties.
- A possible role of low temperature (-2.5° C) in the initial development of external browning on Thompson Seedless grapes was demonstrated and the severity appeared to plateau at 5 weeks of cold storage

For benchmarking purposes, additional populations of Regal Seedless and Thompson Seedless grapes were sourced from commercial export farms and cooled to -0.5° C, using similar methodology and equipment as in the experiments already discussed. The levels of external and internal berry browning showed a high degree of variation between different populations and cultivars (Table 1).

Hence, the overall results suggest that cooling at -2.5°C may occasionally be implicated in the development of internal browning, but that the impact would be dependent on the inherent browning potential of different populations of grapes. In similar research, Ngcobo et.al (2008) found that forced-air cooling to end-point temperatures of 3°C, 1.5°C and -0.5° C prior to export in a refrigerated container, did not significantly influence external and internal berry browning after cold storage. Based on these collective findings, the focus of the industry's grape berry browning research has been redirected towards grape cultivation and harvest practices.

Figure 1: Various types of berry browning symptoms on white seedless grapes, showing mottled (A), peacock (B) and a mix of net-like and glassy berry browning (C).

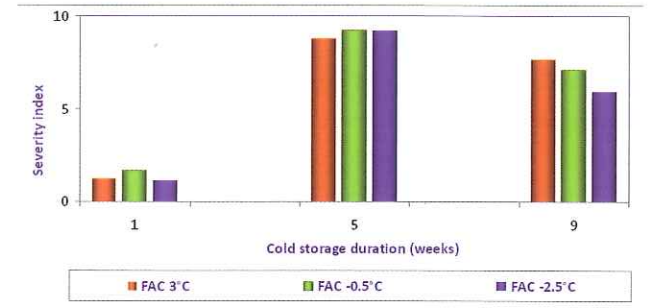

Figure 2: External berry browning on Regal Seedless grapes after forced-air cooling to different pulp end-point temperatures and cold storage at -0.5° C.

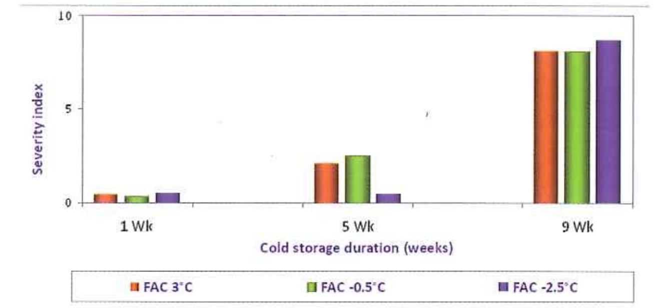

Figure 3: Internal berry browning on Regal Seedless grapes after forced-air cooling to different pulp end-point temperatures and cold storage at -0.5° C.

Figure 4: Variation in browning incidence between individual grape bunches from the same box as indicated by the healthy berries remaining on the rachis after removal of all berries exhibiting browning symptoms.

Table 1: Berry browning index in different populations of Regal Seedless and Thompson grapes after FAC for 24h at -0.5°C and 6 weeks storage at -0.5°C.

PARAMETER	GRAPE POPULATION			
	Regal Seedless 1	Regal Seedless 2	Thompson Seedless 1	Thompson Seedless 2
External browning	69.8	86.5	9.4	3.1
Internal browning	1.5	5.2	0.14	1.31

Other unidentified production or handling factors are indicated as the primary cause of grape berry browning

These results therefore suggest that as long as good refrigeration practices are followed within the current industry guidelines, other, yet unidentified factors are indicated as the primary cause of berry browning.

References

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