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Investigating the potential of a humidification system to control moisture loss and quality of 'Crimson Seedless' table grapes during cold storage

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ABSTRACT

The potential of humidifying cold storage rooms to control moisture loss and quality of table grapes in different package designs was studied. Fruit were stored in cold rooms (−0.33 ± 0.32 °C or −0.12 ± 0.32 °C) with humidifier (95.0% RH) or no humidification (90.3% RH) respectively. Room humidification resulted in a 7.5% and 9.0% increase in RH inside the clamshell and open-top punnets multi-scale packages respectively in comparison to non-humidified storage, while there was no significant change in RH inside the 4.5 kg carry bag multi-packaging. The grapes were assessed for weight loss and SO_2 injury at intervals during a 35 d period. After 21 d of cold storage under humidification, weight loss of grapes was significantly higher ($P < 0.05$) in packages with open-top punnets than clamshell punnets and carry-bags. After 35 days in non-humidified cold storage, grape weight losses were 1.45 ± 0.32%, 1.62 ± 0.21% and 2.01 ± 0.57% for the 4.5 kg carry-bag, 5 kg clamshell punnet and 5 kg open-top multi-packages, respectively. When fruit were stored inside the same types of multi-packages under humidification, the corresponding weight losses were 0.97 ± 0.34%, 1.08 ± 0.27% and 2.00 ± 0.57%. Cold storage humidification reduced the rate of stem dehydration and browning; however, it increased the incidence of SO_2 injury in table grape bunches and caused wetting of the packages.

1. Introduction

Rapid moisture loss is one of the main quality problems affecting table grapes during postharvest handling and is characterized by mass loss (Ngcobo et al., 2012b), shrivelled stems which usually become brittle and break easily, and browning of the dry stems which usually occurs at the advanced stages of shrivel (Nelson, 1978; Lichter et al., 2011; Ngcobo et al., 2012a, 2013a). Grape berries only show symptoms of moisture loss at about 3–5% of bunch weight loss (Nelson, 1978), while the stems start to show signs of dehydration immediately after commencement of weight loss as low as 1% (Ngcobo et al., 2012a). High water vapour pressure deficit (WVPD) due to low relative humidity (RH) of the cooling air has been reported to be the main driving force behind moisture evaporation from fresh commodities stored under refrigerated storage conditions (Sastry, 1985; Thompson et al., 1998; Paull, 1999). High RH and low temperature storage environments play an important role in maintaining the quality of produce (Hung et al., 2011). To reduce moisture loss and preserve postharvest quality during commercial shipment, table grapes are pre-cooled to sub-zero temperatures of −0.5 °C (Ngcobo et al., 2012a). However, moisture loss still remains a challenge inside refrigerated storage rooms.

In many cold storage rooms, temperature is controlled but RH is not. In such cases, maintaining the desired RH depends on a wide range of factors including the surface area of the refrigeration evaporator coil inside the storage room, temperature difference between the coil and the room air, air exchange rates, temperature distribution in the room, type of commodity and packaging material (Paull, 1999). Humidification has been reported to reduce weight loss and maintain quality of fresh produce inside cold stores (Delele et al., 2009a; Hung et al., 2011) and on retail display cabinets (Brown et al., 2004; Moureh et al., 2009). Although humidification has proven to be successful in controlling weight loss and maintaining quality of produce, some drawbacks have been noted in the literature, including wetting of corrugated boards

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Fig. 1. Table grape multi-scale packaging: (a) 5 kg punnet multi-packaging box and (b) 4.5 kg bunch carry-bag multi-packaging box.

(packaging) under a high humidity environment, which causes weakening of cardboard strength and often leads to packaging collapse and ultimately to mechanical damage of produce (Marcondes, 1992; Hung et al., 2010). Mist fogging has also been reported to enhance the development of favourable environments for microbial growth (Brown et al., 2004). Wetting of the surface of produce also causes the stomata to open, thereby contributing to water loss (Hung et al., 2011). However, nano-mists have been reported to alleviate these drawbacks, whilst providing high humidification. This success has been attributed to the generation of droplets which evaporate easily and quickly before causing wetting of produce and packaging (Hung et al., 2010, 2011; Saenmuang et al., 2012).

The recommended storage condition for table grapes is 95% RH at −0.5 °C (PPECB, 2012). Lichter et al. (2011) investigated the effects of WVPD on physical and visual properties of grape rachis (stems) under ambient temperature conditions of 10 °C and 20 °C. Their results suggested that some cultivar differences may exist in terms of response to WVPD, where the rachis of 'Thompson Seedless' grapes remained green at high RH under both 10 °C and 20 °C, while the rachis of 'Superior Seedless' grapes suffered extensive browning at high RH under 20 °C. In this study the effects of humidification on table grape quality under cold storage at −0.5 °C and in different multi-scale packaging was investigated.

2. Materials and methods

2.1. Fruit and packaging

'Regal Seedless' grapes were harvested, prepared and packed from a farm in the Worcester area of Cape Town, South Africa and transported in an air-conditioned car to the Postharvest Technology Research Laboratory at Stellenbosch University. The grapes were packed in three different types of vented multi-scale packaging: 5 kg carton boxes with dimensions of 0.4 m × 0.3 m × 0.13 m (containing clampshell punnets) and 0.6 m × 0.4 m × 0.9 m (containing closed top punnets), respectively (Fig. 1a), and 4.5 kg cartons containing bunch carry-bags (Fig. 1b). Depending on the size of the grape bunch, 6–8 bunches in carry bags were packed in 4.5 kg boxes, while 10 punnets were packed in each 5 kg box. The bunch carry bags and punnets were packed inside perforated liner films (120 mm × 2 mm and 114 mm × 4 mm perforated liner films for the 4.5 kg and 5 kg boxes, respectively) inside carton boxes. The

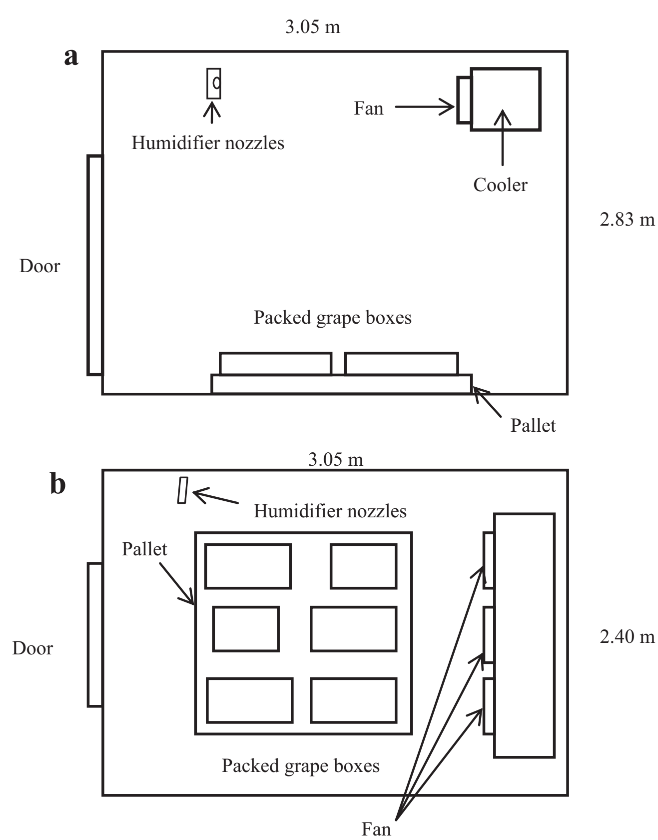

Fig. 2. Experimental set-up inside the cold storage room: (a) side view and (b) top view.