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RIND MOISTURE LOSS - THE CAUSE OF COLD DAMAGE IN HARVESTED AVOCADO FRUIT?

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ABSTRACT

Export of South African avocados to European markets necessitates cold storage during a sea voyage lasting three to four weeks. Internal physiological disorders such as grey pulp, pulp spot and vascular browning as well as pitting and blackening of the rind (cold damage) are associated with cold storage. Moisture loss as a possible cause of cold damage was investigated. Moisture was rapidly extracted from late season 'Fuerte' fruits by placing them in sealed jars connected to a vacuum pump and a refrigerated condensation trap. A vacuum was applied and three different levels of moisture were removed, namely 2%, 4% and 6% by mass, where after the fruit was stored at 5.5°C for four weeks. Fruit from all three treatments developed cold damage symptoms, the severity of which increased with increasing levels of moisture loss. In some fruit, a 6% moisture loss produced brown pits around the lenticels before fruit were placed in cold storage. The severity of the symptoms on these fruits increased once they were placed in cold storage. When the fruit was eating ripe, no internal physiological disorders were observed but anthracnose infection was high. These results suggest that cold damage occurs as a result of moisture loss during or prior to cold storage.

INTRODUCTION

A large percentage of avocado fruit grown in South Africa is exported to European markets by sea. The time from harvest to arrival in Europe ranges from 21 to 28 days during which the fruit is stored at temperatures around 5°C. Avocados are susceptible to chilling injury which manifests itself as pitting and blackening of the exocarp, vascular browning and grey discolouration of the mesocarp (Paul, 1990). This paper deals with exocarp pitting and blackening (hereafter termed 'cold damage' (Swarts, 1984)) in relation to water loss prior to cold storage.

MATERIALS AND METHODS

Late season 'Fuerte' avocados were harvested in mid-September from 7 year old trees on 'Duke 7' rootstock at Everdon Estate near Howick in the Natal midlands. The fruit was picked in the early morning from unstressed trees to ensure that it was turgid. Each fruit was weighed individually. The average fruit haas was 226g. The fruits were placed in jars connected to a vacuum pump and refrigerated condensation trap. A vacuum of -90 kPa was applied which facilitated rapid moisture removal from the fruit.

Three different levels of moisture were removed, viz. 2%, 4%, and 6% of the fruit haas, after which they were placed in cold storage at 5.5°C. Each treatment had 20 replicates. A further 20 fruits were placed directly into cold storage and served as a control. The approximate times taken to remove 2%, 4% and 6% of the fruit haas were 2, 5 and 6h respectively.

After 14 days in cold storage, the fruits were rated for severity of cold damage on a scale of 1-3 (1 = slight; 2 = moderate and 3 = severe) A weighted average for a chilling injury index was calculated by multiplying the number of fruit in each rating by the designated number and taking an average (McCornack, 1976).

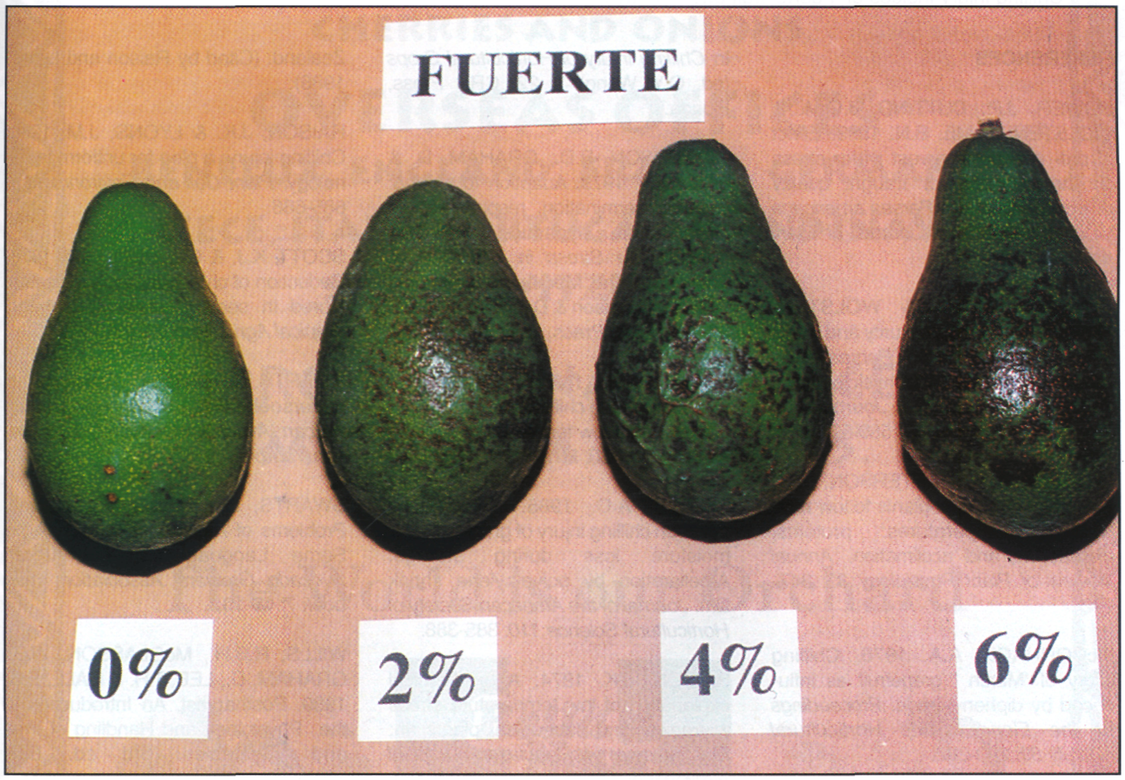

FIG 1.
'Fuerte' fruit after 14 days at 5.5ºC after different levels of moisture loss before storage, showing cold damage symptoms.

RESULTS

Rapid moisture removal from the fruit prior to cold storage produced cold damage symptoms on the rind, whereas the control fruit were unaffected during the four week storage period at 5.5°C. Cold damage developed within 48h of treated fruit being placed in cold storage, the severity of which was related to the amount of water lost prior to cold storage, with 2% loss being the least severe and 6% loss the most severe (Figs 1 & 2). The 2% treatment caused pitting and blackening only around the lenticels. Removal of 2% and 4% moisture resulted in the spread of the blackened areas so that they coalesced. The severity of the black cold symptoms increased gradually during storage. It is interesting to note that some fruit developed brown pits around the lenticels before being placed into cold storage, when more than 4% moisture had been removed. When eating ripe, as determined by a firmometer (Swarts, 1981), the fruit with cold damage did not show internal physiological disorders such as mesocarp discolouration. The incidence of anthracnose was high. Vascular discolouration associated with stem-end rot occurred in some fruits.

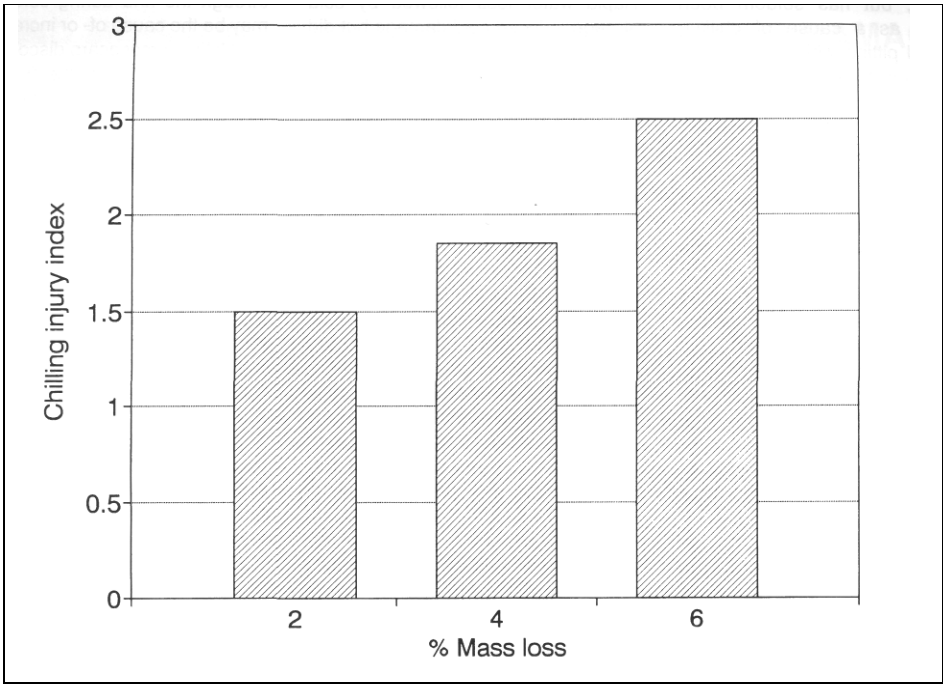

FIG 2. Chilling injury indices of 'Fuerte' fruit after 14 days at 5.5°C

DISCUSSION

Chilling injury occurs in two stages: a primary event occurs, which is then followed by a series of secondary events. A number of possible primary events have been put forward e.g. a change in membrane lipid structure (Raison, 1974), or a conformational change in some structural proteins or regulatory enzymes (Graham and Patterson, 1982) or cytoskeletal changes in the cell (Patterson et al., 1979). The primary event is thought to occur instantaneously once the plant reaches its critical chilling temperature and is reversible if the chilling temperature is of short duration (Raison and Lyons, 1986). Secondary events include cessation of cytoplasmic streaming, impairment of ion movement through membranes, respiration, photosynthesis and protein synthesis all of which give rise to membrane breakdown and the resultant visual symptoms of chilling injury (Wills et al., 1989).

Moisture loss from the fruit could aid membrane breakdown, resulting in a loss of cell compartmentation which gives rise to visual chilling injury symptoms, but has seldom been implicated as a cause of chilling injury. Rind pitting which is a symptom of chilling injury in grapefruit was reduced by wrapping the fruit in polyethylene shrink film to reduce water loss (Purvis, 1985). Pitting was also found to occur in areas of the grapefruit rind where diffusive resistance was lowest (Purvis, 1984). This experiment shows that the severity of cold damage is related to the degree of moisture loss from the fruit. Cutting and Wolstenholme (1992) found that fruits not cold stored lost more moisture during ripening than those cold stored. However, symptoms of cold damage only occur in cold stored avocados, indicating that moisture loss increases the susceptibility to this disorder.

The brown pits observed around the lenticels of some of the treated fruits before cold storage were probably as a result of severe cell damage due to the rapid rate of moisture loss induced by placing the fruit in a partial vacuum.

Rapid water loss followed by cold storage induced cold damage but did not cause internal discolouration, probably because most of the moisture lost was from the rind. Bower et al. (1989) found that humidification of the storage atmosphere to reduce evaporative demand during cooling reduced the incidence of pathological and internal physiological disorders in avocado fruit. Scott and Chaplin (1978) reported a reduction of mesocarp discolouration in 'Hass' and 'Fuerte' avocados stored in sealed polyethylene bags. They attributed this to a modified atmosphere in the bags with CC-2 concentrations ranging from 3 to 7 % and 2 to 6 % O_2. In the light of the results obtained by Bower et al. (1989) it seems that a reduction of water loss also played a role in reducing mesocarp discolouration. Passive water infusion through the pedicel of avocado fruit during cold storage at 5.5°C for 28 days totally inhibited mesocarp discolouration (Cutting and Wolstenholme, 1992). It therefore seems that moisture loss through the pedicel and especially through the rind during cold storage may be the cause of or increase susceptibility to mesocarp discolouration. Judicious waxing of the fruit should greatly reduce the incidence of cold damage, but cold damage occurs fairly commonly in waxed export fruit, indicating that it is necessary to maintain fruit turgidity right from the time of harvest. Practical measures such as pre-harvest irrigation, minimisation of fruit moisture loss in transit to and in the packhouse, and during cold storage are necessary to reduce cold damage. Restricting harvesting to the cooler parts of the day will also help reduce moisture loss.

In conventional cooling systems there is a high evaporative demand during initial cooling and consequent water loss from the stored produce. Hydrocooling (cold water baths) and humidification may be effective ways of reducing moisture loss during avocado storage and further research is needed in these areas.

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