Environmentally Friendly and Safe Technologies for Quality of Fruits and Vegetables

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The papers contained in this book report some of the peer reviewed Proceedings of the International Conference "Environmentally friendly and safe technologies for quality of fruit and vegetables", but also other papers related with the subject were included. The manuscripts were reviewed by the Editor and Editorial Board, and only those papers judged suitable for publication were accepted. The Editor wish to thank to all the reviewers and authors for their contribution.

Authors are responsible for content and accuracy of their papers.

Proceedings of the International Conference "Environmentally friendly and safe technologies for quality of fruit and vegetables", held in Universidade do Algarve, Faro, Portugal, on January 14-16, 2009. This Conference was a join activity with COST Action 924.

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SECTION 3. QUALITY MANAGEMENT OF FRUIT AND VEGETABLES

20. WATERCORE DISSIPATION IN 'FUJI' APPLES AT DIFFERENT HOLDING TEMPERATURES

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Abstract
Fruit with high levels of watercore are rejected during market quality control inspections because affected apples can develop alcoholic off-flavours and internal browning symptoms. In 2007 and 2008 late harvest 'Fuji' apples with a high incidence of watercore were kept at 1 °C (2008), 3 °C (2007), 6 °C and 10 °C in air. Some fruit at 10 °C were also treated with 1-MCP and Ethephon. Changes in flesh firmness and watercore were followed during 51 d storage. Fruit at 1, 3 °C and 1-MCP treated fruit at 10 °C showed no clear change in flesh firmness during 51 d storage while fruit at 6 °C softened between 0.7 and 0.9 kg/cm^{-2} and untreated fruit at 10 °C lost around 1.0 kg/cm^{-2}. Watercore in 'Fuji' apples with or without 1-MCP or Ethephon treatments at 10 °C dissipated to acceptable levels after around 16 to 22 d, while apples at 6, 3 and 1 °C showed acceptable watercore at 26, 29 and 51 d respectively. When 'Fuji' apples have high levels of watercore at-harvest, one option is to treat them with 1-MCP and store at 10 °C. The watercore will reduce rapidly but fruit flesh firmness will generally be maintained at acceptable levels.
Keywords: 1-MCP, fruit firmness, *Malus domestica*, physiological disorders

Introduction
Apples with watercore accumulate sorbitol-rich solutions within the fruit flesh intercellular spaces. This physiological disorder occurs while fruit are still on the tree and symptoms appear in the fruit flesh as hard and glassy water soaked areas (Dart & Newman 2005). Watercore reduces the market and storage options available for the fruit as affected apples can develop an alcoholic taste and internal breakdown symptoms especially when stored under controlled atmosphere conditions (Argenta *et al.* 2001). Consumers can also be confused by the unusual and curious symptoms and more severely affected apples are normally rejected at official quality control inspections. Watercore incidence varies with season and cultivar, however, in 'Fuji' apples watercore can dissipate during storage (Brackmann *et al.* 2001) and it is usual for apples with high watercore levels to be held for a period to allow the watercore to dissipate before the fruit are marketed. However, the rate of watercore dissipation is not known and not quantified in relation to either: the storage temperature; other postharvest treatments like 1-MCP and Ethephon applications; or changes in the key fruit quality parameters such as flesh firmness.

Material & Methods
Two experiments were conducted in 2007 and 2008 with late-harvest high watercore 'Fuji' (mutant 'Kiku') apples from the Competence Centre for Fruit Growing, Ravensburg, Southern Germany. Fruit were sorted and randomly allocated into 1 (2008), 3 (2007), 6 and 10 °C storage temperature treatments. In 2008, 1-methylcyclopropene (1-MCP) and Ethephon were also applied to fruit at 10 °C. Fruit samples were regularly taken over a 51 d storage period to determine watercore and fruit flesh firmness. Treatment lots comprised 100 fruit in 2007 and 60 fruit in 2008, with individual fruit as replications.

Apples were cut transversally through the equatorial region and watercore incidence scored against reference photographs from 0 to 5 (0 = no watercore and 5 > 40% of the cut flesh area, Fig 1). Apples with an average watercore score of < 2.5 were considered commercially acceptable.

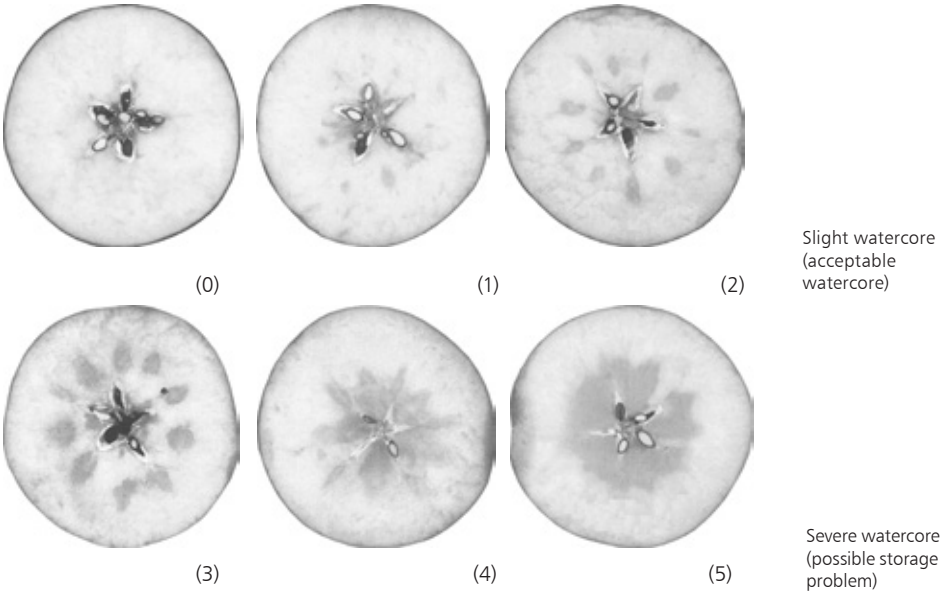


Fig 1. Reference table for watercore occurrence with a range of 0 to 5 (0 represents fruit without watercore and score 5 indicates 40% of flesh with watercore (maximal score).

Flesh firmness was measured from the equatorial region of the apple between the green/yellow (shaded side) and red blush (sun exposed side) the skin was removed and a fruit texture analyser (Güss, South Africa) with an 11 mm diameter tip used to determine fruit flesh firmness as kg cm^{-2}. Flesh firmness readings are an average of 3 repetitions each of eight fruit.

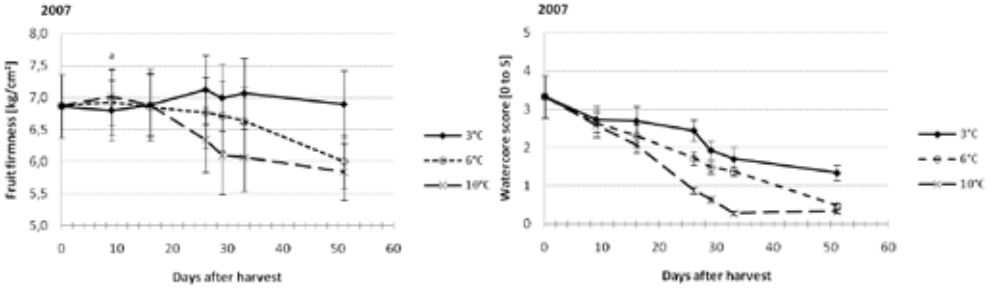
The experimental design was completely randomised and the standard deviation was calculated.

Results & Discussion

Fruit held at 1, 3 and 10 °C plus 1-MCP showed no clear changes in flesh firmness during 51 d storage, while fruit held at 6, and 10 or 10 °C plus Ethephon softened between 0.7-0.9 kg cm^{-2} and by around 1.0 kg cm^{-2} respectively (Fig 2A, 3A). These results confirm the potential of 1-MCP to maintain the flesh firmness in apples (Watkins 2008), and even though the 1-MCP treated fruit were held at 10 °C the softening rate was similar and slightly slower than fruit held at 1 °C without 1-MCP (Fig 2A, 3A).

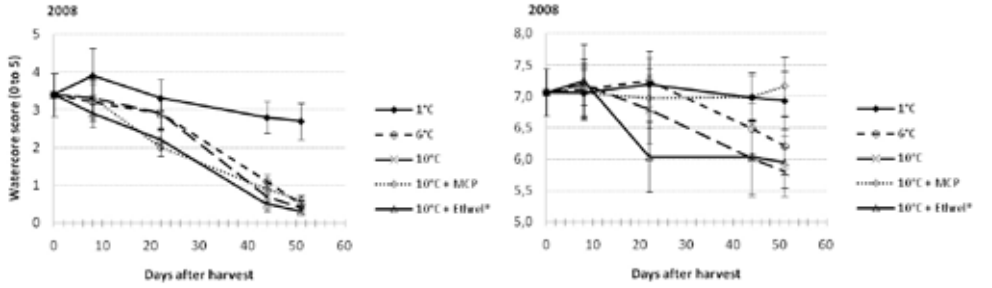
'Fuji' apples at 10 °C showed acceptable watercore levels (< 2.5) after 16 to 22 d and the 1-MCP or Ethephon treatments had no additional inhibitory or promoting effect. Apples at 6 °C had acceptable levels of watercore after 16 d in 2007 and 26 d in 2008. Fruit held at 3 °C achieved this level after 29 d in 2007 (Fig 2B), apples held at 1 °C achieved this level after 51 d in 2008 (Fig 3B). The reason for the differences in watercore dissipation between the two years is not clear, but comparing both years, a general slower ripening progress of the apples was observed in 2008 (Kittemann 2008). Storage temperature has a clear effect on watercore dissipation rates but the rate varied between the two years. Brackmann *et al.* (2001) also found watercore dissipated during storage. However, as the 1-MCP and Ethephon treatments did not influence the rate of watercore dissipation, this suggests ethylene induced effects are not involved in watercore dissipation and other processes such as transpiration could be, as also suggested by other workers (Marlow & Loescher 1984; Ferguson *et al.* 1999; Yamada *et al.* 2004).

When 'Fuji' apples show high levels of watercore at-harvest one option is to treat them with 1-MCP and then store at 10 °C. This will rapidly dissipate the watercore but maintain fruit flesh firmness within generally acceptable levels.



(a) (b)

Fig 2. Reductions in flesh firmness (A) and watercore dissipation (B) for 'Fuji' apples held at three different temperatures in 2007 (..... approx quality inspection acceptance limit in watercore). The error bars represent SD, n=100 (watercore), n=24 (fruit firmness).



(a) (b)

Fig 3. Reductions in flesh firmness (A) and watercore dissipation (B) for 'Fuji' apples held at three different temperatures in 2008 (..... approx quality inspection limit in watercore index). The error bars represent SD, n=60 (watercore), n=24 (fruit firmness).

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