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Tackling the Pinkerton problem

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ABSTRACT

It is no secret that the Pinkerton cultivar has been receiving considerable attention in the last few years. Unfortunately, not much has been in a positive light. Although Pinkerton are heavy bearing green skins, the development of intense mesocarp blackening after storage has hindered the export this cultivar. Many factors have been attributed to causing the disorder but few studies have been conclusive. In this study the role of postharvest shipping temperatures was investigated by storing fruit from various areas at 8°C, 5.5°C and 2°C for 30 days followed by ripening at 20°C. Following storage, membrane stability, internal blackening and respiration rates were monitored. It was found that temperatures below the recommended shipping temperature produced the best quality fruit, i.e. 2°C. This was supported by the membrane stability studies that showed more membrane collapse at the warmer temperatures of 8°C. Throughout the study carbon dioxide evolution rates were seen to increase as fruit maturity increased, perhaps explaining why the lowest temperature treatment produced the best results as respiration rates could be suppressed. Fruit origin proved to have an effect on fruit physiology as differences were observed in respiration rates between growers and regions. Pre-harvest conditions proved to be important, as growers within the same area produced fruit with marked quality differences. Future work will attempt to identify the relevant pre-harvest factors starting with mineral and phenolic studies. Potassium and nitrogen levels are suspected to play important roles, as well as some micronutrients.

INTRODUCTION

The occurrence of mesocarp discoloration in the avocado cultivar 'Pinkerton' has seriously affected the production and export of this high yielding green skin. While mesocarp discoloration has been observed in many other cultivars, the cause of the disorder in 'Pinkerton' has not been successfully identified despite the research that has already been conducted. The disorder was initially thought to be aggravated by extended cold storage. Unfortunately increasing the shipping temperature has not alleviated the problem. This study was undertaken to ascertain the role of postharvest temperature in the development of the disorder, while trying to attain a better understanding of the fruit's physiology and determine possible mechanisms through which certain macro factors initiate cellular collapse, both pre- and postharvest. Van Rooyen and Bower (2001) reported initial studies on this disorder, whilst more recent results are presented here.

MATERIALS AND METHODS

As in the previous study (Van Rooyen & Bower, 2001) fruit were obtained from different production areas of varying mesocarp discoloration histories. Fruit were subjected to normal packhouse procedures, and dispatched by overnight courier to Pietermaritzburg for further treatment and analysis. On arrival the fruit were divided into eight treatments (five fruit per treatment), see Table 1.

Evaluations of fruit quality, membrane stability and internal blackening were made

Table 1. Treatments used to establish the role of temperature in disorder development.

Treatment	Storage temperature	Storage period
1	*(not stored)	(not stored)
2	20°C	Until soft
3	8°C	30 days
4	8°C	30 days
	20°C	Until soft
5	5.5°C	30 days
6	5.5°C	30 days
	20°C	Until soft
7	2°C	30 days
8	2°C	30 days
	20°C	Until soft

* Sampled on arrival

before and after storage as well as after softening. Once removed from storage, fruit softness and respiration rates were monitored daily. Eating ripeness was determined with a hand held densimeter.

Membrane integrity tests

Membrane integrity was determined using a modified technique of Venkatarayappa, Fletcher & Thompson (1984). Mesocarp disks were shaken for three hours in 25 mL distilled water after which the electrical conductivity (EC) of the solution was measured (referred to as initial EC). The disks were then boiled for 20 minutes, allowed to cool and the EC measured again (final EC). The difference between the initial and the final reading, as a proportion of initial value, was used to calculate the solute leakage percentage.

Discoloration ratings

Fruit were cut in half (longitudinally) and discoloration rated on a scale of 0 to 10, where 0 indicated no discoloration and 10 severe blackening. The presence of any other disorders / pathogens was also noted and scored (0 = absent, 1 = present).

Respiration

The rate of carbon dioxide (CO_2) evolution was determined every day using an environmental gas monitor. Each fruit was sealed in a jar for 10 minutes and the initial and final CO_2 concentration determined and adjusted for fruit weight and volume.

Maturity

Maturity was ascertained by determining the moisture content of a sample of mesocarp tissue, using a freeze drier.

Soil samples

Soil samples were obtained from the orchards used during the study, at the end of 2001, and sent for mineral analysis. Samples were taken at the following depths 30, 60 and 90 cm.

RESULTS AND DISCUSSION

When looking over the whole research period it was found that mesocarp discoloration varies between seasons with internal fruit quality being disastrous during 1999, fairly good in 2000 but relatively poor again in 2001.

Temperature

During 2001 a very strong trend developed with the highest storage temperature of 8°C giving the highest percentage discoloration and 2°C the least. This trend held true for fruit from all the different farms used, unlike during the 2000 season where results appeared to differ between growers. While these results appeared positive, in as far as mesocarp discoloration was reduced at the lower temperatures, this was negated by the fact that external chilling injury was more frequent at these temperatures.

Membrane integrity

The method used in 2000 was refined in 2001, providing clearer trends. In all the treatments sampled immediately after storage the solute leakage percentages increased with increasing storage temperatures. High leakage may in theory be as a result of some membrane breakdown during storage leading to the enzyme PPO coming into contact with its phenolic substrate, normally resulting in a browning reaction. However, to what degree the membrane breakdown is naturally affected by a faster softening (Fig. 1) at the higher storage temperatures, still need to be determined. A higher rate of softening will require a greater energy source for respiration. The carbohydrate status of the fruits were unknown, but it is suggested that once the source of carbohydrate in the fruits is depleted, alternative energy sources such as lipids will need to be mobilized. Should a deficiency in energy occur, stress would result with membrane damage.

However, temperature alone is not believed to be the primary causative agent in browning, as treatments showing high solute leakage during 2000 did not necessarily show any worse discoloration than the other treatments, and grower differences were observed. Increased temperature and therefore respiration rate may merely aggravate discoloration in fruit predisposed to browning potential. This is considered to be affected by pre-harvest conditions. It has been found that climatic conditions (*viz,* temperature and drought) may affect the degree of lipid saturation (Quinn, 1988, Woolf *et al.*, 1989). This will in turn affect membrane permeability. Furthermore, Bower and Van Lelyveld (1985) found that the concentration and activity of PPO is affected by pre-harvest water stress in the orchard.

Fruit maturity

The role of fruit maturity was slightly unclear as it had no visible effect on internal quality during 2000 but did appear to play a large role in 2001 (Fig. 2), with more mature fruit showing higher degrees of discoloration. The recommendations made by Kruger *et al.* (2001) to harvest earlier proved to be beneficial as fruit quality deteriorated as the season progressed. The moisture contents of the fruit were found to fluctuate slightly through the season making (over)maturity decisions difficult. Fruit quality from high risk orchards rapidly deteriorated as moisture contents fell below 71% towards the end of the season, while remaining acceptable at 68% in low risk orchards. Caution should therefore be exercised when using fruit moisture content as a maturity indicator to predict the occurrence of physiological disorders. Many pre-harvest conditions can play a role, for example, crop load and mineral concentrations (SAAGA Guideline, 2002).

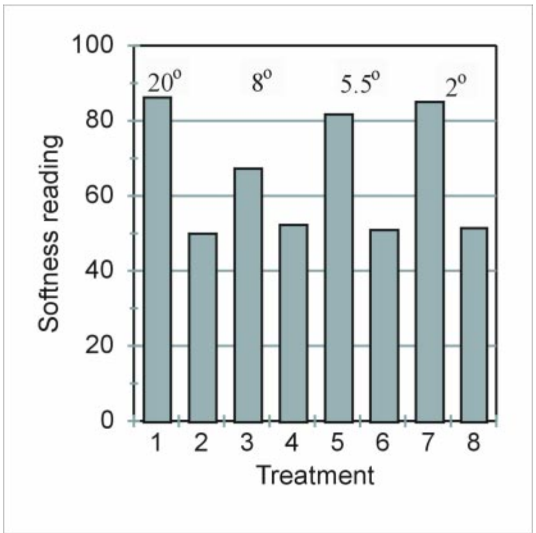

Figure 1. Difference in softness readings once removed from storage. Treatment 1 = fruit sampled on arrival; 2 = sampled on softening (without storage); 3, 5, 7 = sampled after 30 days at designated temperatures; 4, 6, 8 = sampled on softening after storage at respective temperatures.

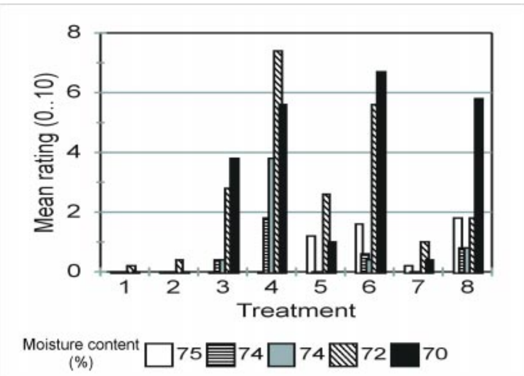

Figure 2. Difference in mesocarp discoloration severity as moisture content decreases.

Respiration

Respiration rates were monitored to give an indication of the overall metabolism of the fruit and appeared to increase as fruit maturity increased. The more mature fruit already starting to soften whilst in storage. During 2001 there was a tendency for fruit which ripened more quickly to display a more intense mesocarp discoloration.

Throughout the season it was noted that fruit from different areas displayed differences in carbon dioxide evolution concentrations (data not shown). Small differences also being noticed between growers in the same area indicated that fruit origin affects the physiology of the fruit.

Fruit origin

It was found that fruit origin plays a large role in the severity of the disorder with large quality differences being observed between the various farms used in the study (Fig. 3). This illustrated the importance of pre-harvest factors (e.g. climate and nutrition) in the development of the disorder. Areas with warm temperatures, good rainfall and very fertile soils characterized for the most part the high risk areas. Orchards on lands previously planted to bananas appeared to fall into high risk areas, possibly due to the heavy applications of nitrogen and potassium used during banana production.

Soils conditions

The ideal soils for avocados have in the past been thought to be soils classified as Huttons and Inandas. In the case of Pinkerton, however, this has not been the case. During 2001 the best fruit quality was observed in trees growing in more sandy soils. While sandy soils are more prone to leaching, this might be beneficial in reducing the vigour of the vegetative flush. It has been found that the vegetative flush competes with fruit for available calcium

(Marschner, 1995). A high calcium content is important for suppressing the respiration rate of a fruit and thus delaying ripening, and extending its shelf life. Cultural adaptations do, however, have to be made to suit the respective soil conditions. The extended use of chicken litter as a mulch will cause soils to contain a high organic matter content. This would result in an uncontrolled release of nitrogen throughout the season and possible problems of excess vigour. It must be mentioned that minerals often interact with each other, and are affected by environmental conditions (Marschner, 1995). In this study, for example, soils that had a high calcium to magnesium ratio – particularly if the magnesium levels were deficient – produced fruit with a relatively poor internal quality. Nutrient ratios are therefore more important than single elements.

(a)

Figure 3. Difference in mesocarp discoloration severity between fruit from a 'high risk' area (a) and a 'low risk' area (b). Fruit from both areas were stored at 8°C.

Possibly important pre-harvest factors

It has been mentioned that differences in climate and cultural practices may play a role in the fruit quality differences noticed between the various areas. Fig. 4 indicates the growth cycle of the avocado. During different months of the year different flushes occur. However, this chart can not be used for all cultivars and production areas. The Natal season, for example, is later than most of the areas in Mpumalanga. It is suggested that the importance of understanding the total growth cycle in a respective area becomes vital during orchard management procedures. For example, an application of fertilizer at the incorrect time can promote a vegetative flush when the reproductive flush is still very vulnerable, thus leading to competition arising between the two flushes for nutrients.

Kruger, Kritzinger & Malumane (2000) observed that fruit from cooler production areas were less susceptible to mesocarp discoloration than the warmer areas and that high rainfall during fruit maturation resulted in more internal disorders. Water stress on the other hand has also been found to aggravate internal discoloration as it affects the concentration and activity of the browning enzyme PPO, mentioned earlier (Cutting *et al.*, 1989). It is therefore suggested that additional knowledge concerning phenology, water and mineral requirements is needed at individual sites, so as to optimally manage cultural practices.

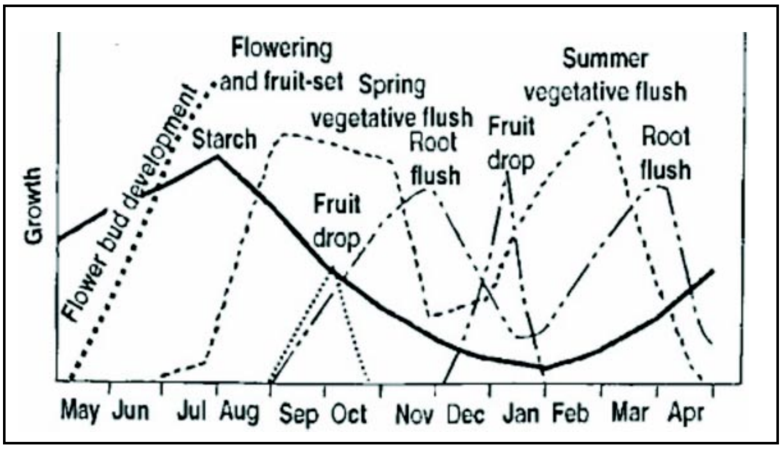

Figure 4. The total growth cycle of cv. Fuerte (Whiley & Wolstenholme, 1990).

CONCLUSIONS

The effects of low temperature storage on internal fruit quality in 2000 were confirmed in 2001. During both seasons the severity of mesocarp discoloration was worse at the higher storage temperatures. Unfortunately external chilling injury / pitting increased at the lowest shipping temperature (2°C) and therefore an optimum temperature between 5.5 °C and 2 °C needs to be established. Nonetheless, the authors still strongly believe that the disorder is initiated pre-harvest. The contributing factors may however differ from area to area as observed by the difference in fruit quality between areas and growers within the same areas. Future work will look at establishing which pre-harvest factors play the largest roles with the aim of implementing management programs to overcome these factors. While there is little that can be done about the weather, irrigation programs (for example) can be managed with reasonable ease. Furthermore, studies on polyphenol oxidase and phenolics should give an indication of the effect of differences in pre-harvest conditions on internal browning potential. Pre-harvest water stresses, as well as certain minerals are known to affect the activity of this enzyme. Mineral studies will therefore also be important, and need to include micro as well as macronutrients.

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