Avocado sugars – key to postharvest shelf life?

I. Bertling and S. Z. Tesfay
Horticultural Science, School of Agricultural Sciences and Agribusiness,
University of KwaZulu-Natal, Pietermaritzburg, South Africa

Abstract

Avocado fruit is prone to a large variety of physiological disorders. These disorders probably occur as a result of a lack of "stress-defence" of the tissue involved. As the two main sugars in mesocarp tissue, *D*-mannoheptulose and perseitol, have been demonstrated to possess antioxidant activity, these sugars were, postharvest, infiltrated into fruit in order to determine if their concentration in the mesocarp can be increased by this means and which effect such treatment would have on fruit quality and shelf life. *D*-mannoheptulose, perseitol and water were either infused once or continuously. Continuous infusion of *D*-mannoheptulose reduced the respiration rate of fruit, indicating that the deterioration of post-harvest quality of 'Hass' avocado might be related to a lack of *D*-mannoheptulose in mesocarp tissue during maturation. This implies the need to search for a means to increase pre-harvest *D*-mannoheptulose concentrations in the mesocarp, as this sugar acts as an anti-oxidant, permitting prolonged post-harvest life of avocado fruit. The continuous infusion of *D*-mannoheptulose increased the shelf life of avocado fruit compared with water infusion or no infusion and improved the fruit quality attributes fruit fresh weight and fruit firmness. *D*-mannoheptulose has a multifunctional role, making the presence of this sugar present in the mesocarp pre- and post-harvest an important factor in maintaining fruit quality. Therefore, increasing or maintaining a certain concentration of this sugar by pre- and postharvest horticultural practises may play a major role in conserving avocado fruit quality.

Keywords: Carbohydrates, *D*-mannoheptulose, infusion, fruit quality, post-harvest

Introduction

Avocado fruit are unique in that fruit which have set at a similar date can be harvested over an extended period; this can stretch in countries like South Africa over six months, resulting in a large difference of fruit maturity (*Pearson*, 1975). Therefore maturity indices are used to determine the earliest possible time when fruit can be harvested. In different countries different indices are used as avocado maturity standards, such as 29-37 % fruit dry matter (*Blakey*, 2011) or as 30-35 % oil (*Tesfay et al.*, 2010). Although exported fruit comply with these norms, ripening of the fruit can be problematic, as experienced when fruit are designated for "ready-ripe" programmes and are ripening unevenly (*Blakey*, 2011). Dry matter of the avocado mesocarp also consists of large quantities of uncommon sugars (*Liu et al*. 1999), particularly the C7 sugars *D*-mannoheptulose and perseitol as well as volemitol (*Cowan*, 2004). As the harvesting season progresses oil and dry matter increase, however, mesocarp phenolics and C7 sugars decrease (*Tesfay et al*., 2010, *Tesfay et al*., 2011). These compounds have been established as major contributor to the antioxidant activity of the mesocarp (*Tesfay et al*., 2010), and are, therefore, likely to be linked with the occurrence of mesocarp disorders, such as mesocarp discolouration and vascular browning, phenomena that increase from the early to the late harvesting season. The C7 sugar mannoheptulose, followed by its isomer, perseitol, provide the majority of antioxidant activity in avocado mesocarp at the time of picking maturity (*Tesfay et al*., 2010), indicating that particularly mannoheptulose could play a pivotal role in protecting the mesocarp from various postharvest storage disorders. If the decline in sugars, and particularly mannoheptulose, is related to the increase in occurrence of postharvest disorders, artificial supply, via infiltrating fruit with these substances, should maintain high postharvest quality. Therefore, fruit of the early-, mid-, and late-season were infused, through the pedicel to maintain a high C7 sugar concentration within the mesocarp to avoid mesocarp quality deterioration.

Materials and methods

Fruit were collected from a 'Hass' avocado orchard in the KZN-Midlands, South Africa (30°16´E, 29°28´S) during the early season (July 25% oil) mid season (September 26 % oil) and late season (November

31 % oil). Four postharvest infusion treatments (non-infused fruit, single or continuous water infusion, as well as single or continuous 9.52mM *D*-mannoheptulose or perseitol infusion) were used according to Bertling *et al*. (2011).

Fruit firmness, fresh weight loss, respiration and mesocarp mannoheptulose and perseitol concentrations were monitored (*Tesfay et al.,* 2010; *Tesfay et al.,* 2011) over a ten day period. During infusion the mesocarp sugar concentration was determined for alternate days until fruit became eat-ripe (softness 50.0 to 62 N). When fruit were soft, their internal quality was evaluated and rated on a scale from "0" (no blemishes) to "5" (severely blemished).

Results

Overall results for the harvesting seasons followed the same trend.
Throughout the harvesting period *D*-mannoheptulose-infused fruit had the lowest weight loss, followed by water-infused fruit, while control fruit, which still had the pedicel attached) had the highest weight loss (Fig. 1). These mannoheptulose-treated fruit were also the firmest (Fig. 2) throughout the seasons, followed by water-infused ones. Differences between treatments remained significant, even ten days after treatment. Similarly, the infusion of water and watery sugar solution reduced the loss of fruit firmness (Fig. 2).
Fruit physiology was also significantly affected by the sugar infusion, with the mannoheptulose infusion resulting in a lower respiration rate than that of control fruit; however, infusion of water also reduced respiration significantly compared with the control (Fig. 3). Continuous *D*-mannoheptulose infusion resulted in the highest mesocarp concentration of this sugar, with water-infused fruit containing the second highest concentration (Fig. 4). The control had the lowest mesocarp mannoheptulose concentration. Fruit quality was significantly affected by treatment, with continuous mannoheptulose infusion resulting in the best internal quality, followed by water-infused fruit and finally the control.

Conclusions and recommendations

Postharvest quality parameters of 'Hass' avocado are significantly affected by the continuous supply of water and endogenous sugar. As continuous infusion of *D*-mannoheptulose reduces the fruit respiration rate, the deterioration of post-harvest quality of ‘Hass’ avocado might, at least in part, be due to a lack of *D*-mannoheptulose in mesocarp tissue. Mannoheptulose infusion not only affects fruit firmness, but also respiration and therefore shelf life. We therefore confirmed earlier assumption by *Bertling and Bower* (2006) that the rare sugars found in avocado play an important role for fruit quality. We postulate that the sugar *D*-mannoheptulose is a compound of paramount importance in avocado fruit quality, possibly through acting as an anti-oxidant, permitting longer post-harvest storage of the avocado fruit. This implies the need, firstly, to search for means to increase the *D*-mannoheptulose concentration pre-harvest as well as, secondly, to search for technologies that reduce the loss of this sugar in the mesocarp post-harvest.

Acknowledgements

Financial support for this study by the South African Avocado Growers' Association is gratefully acknowledged.

References

Bertling, I. and Bower, J.P. 2006. Avocado sugars during early fruit development. *South African* Avocado Growers’ Association Yearbook 29: 38–39.

Bertling, I., Tesfay S. Bower J. P., and Mohamed Ahamed Ali, N. G. 2011. *D*-mannoheptulose: Special carbohydrate in avocado: Presence postharvest and commercial importance. Acta Horticulturae (in press).

Blakey, RJ. 2011. Management of postharvest avocado physiology PhD thesis University of KwaZulu-Natal, pp196

Cowan, AK 2004: Metabolic control of avocado fruit growth: 3-hydroxy-3-methylglutaryl coenzyme a reductase, active oxygen species and the role of C7 sugars; South African Journal of Botany 70(1): 75–82.

Liu, X., Robinson, P.W., Madore, M.A., Witney, G.W. and Arpaia, M.L., 1999. 'Hass' avocado carbohydrate fluctuations. I. Growth and phenology. Journal of the American Society for Horticultural Science 124, 671–675.Pearson, D. 1975. Seasonal English market variation in the composition of South African and Israeli avocados. J. Sci. Food Agri. 26:207-213.

Pearson,

Tesfay, S.Z., Bertling, I. and Bower, J.P. 2010. Anti-oxidant levels in various tissues during the maturation of 'Hass' avocado (*Persea americana* Mill.) Journal of Horticultural Science and biotechnology 85 (2): 106-112.

Tesfay, S.Z., Bertling, I. and Bower, J.P.. 2010. Anti-oxidant levels in various tissues during the maturation of ‘Hass’ avocado (*Persea americana* Mill.). Journal of Horticultural Science and Biotechnology 85: 106-112.

Tesfay, S.Z., Bertling, I. and Bower, J.P. 2011 Effects of Postharvest Potassium Silicate Application on Phenols and Other Antioxidant Systems Aligned to Avocado Fruit Quality. Journal of Postharvest Biology and Technology 60: 92–99.

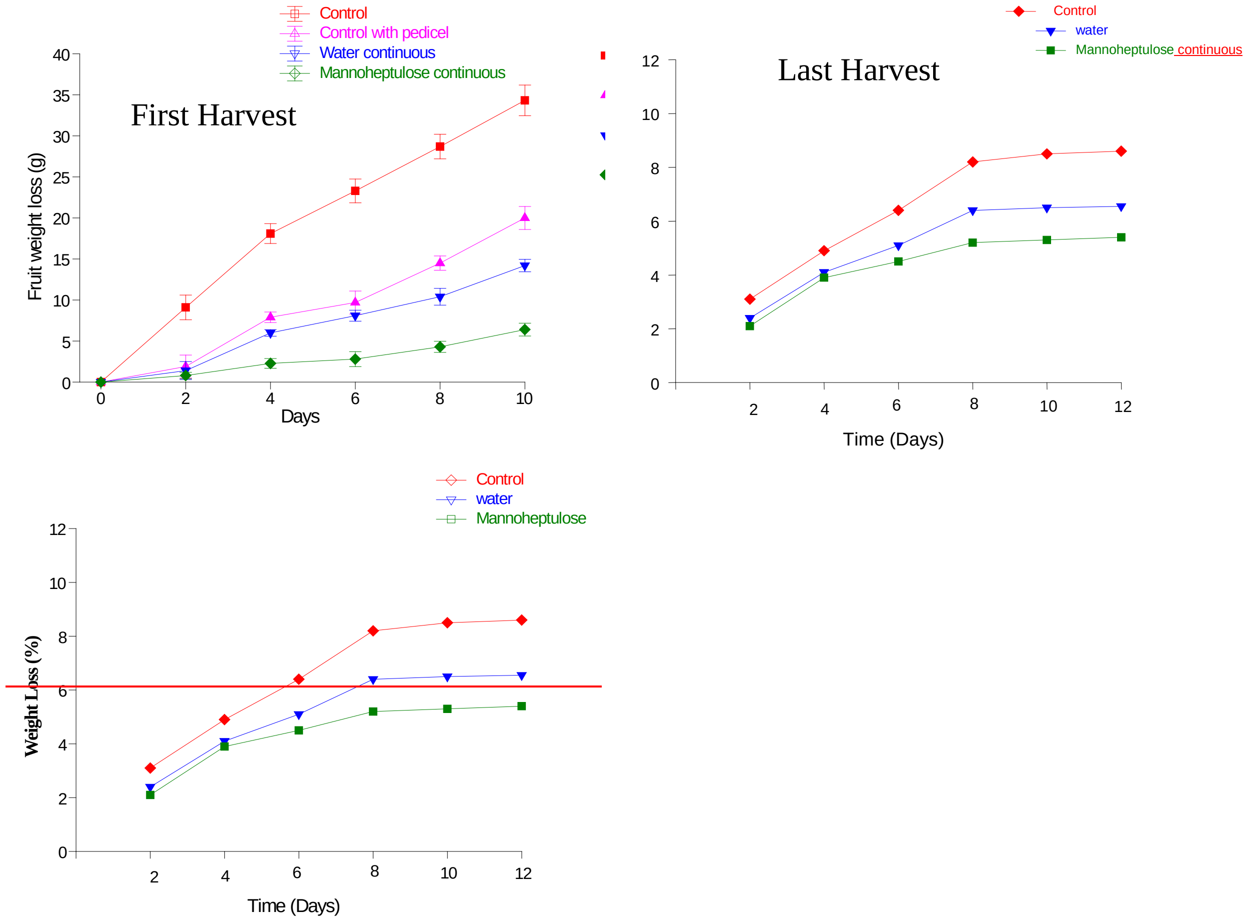

Fig. 1 Fresh weight loss of 'Hass' avocado fruit treated with continuous water and *D*-mannoheptulose infusions, compared with controls (with and without pedicel)

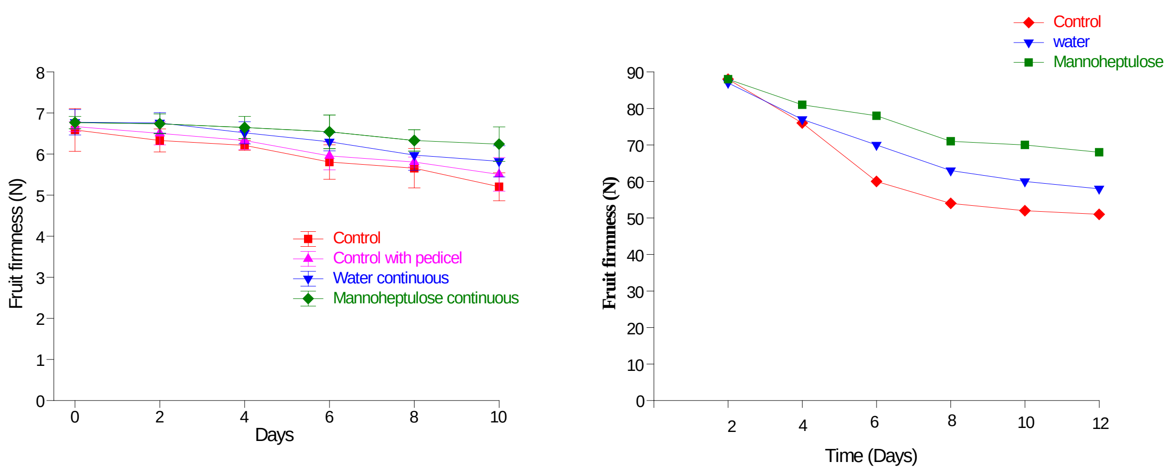

Fig. 2 Flesh firmness of 'Hass' avocado fruit continuously infused with water or *D*-mannoheptulose

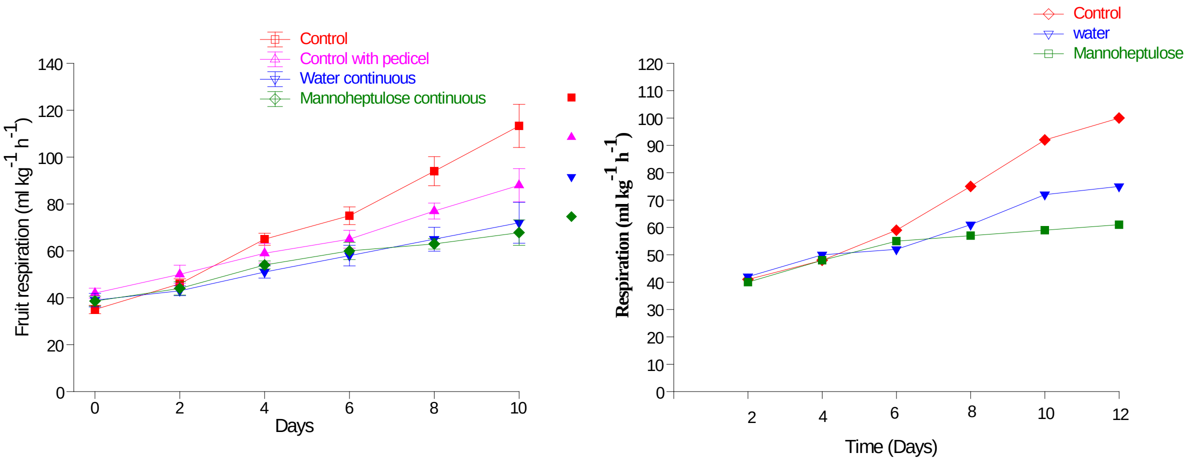

Fig. 3 Respiration rate of ‘Hass’ avocado fruit continuously infused with water or *D*-mannoheptulose

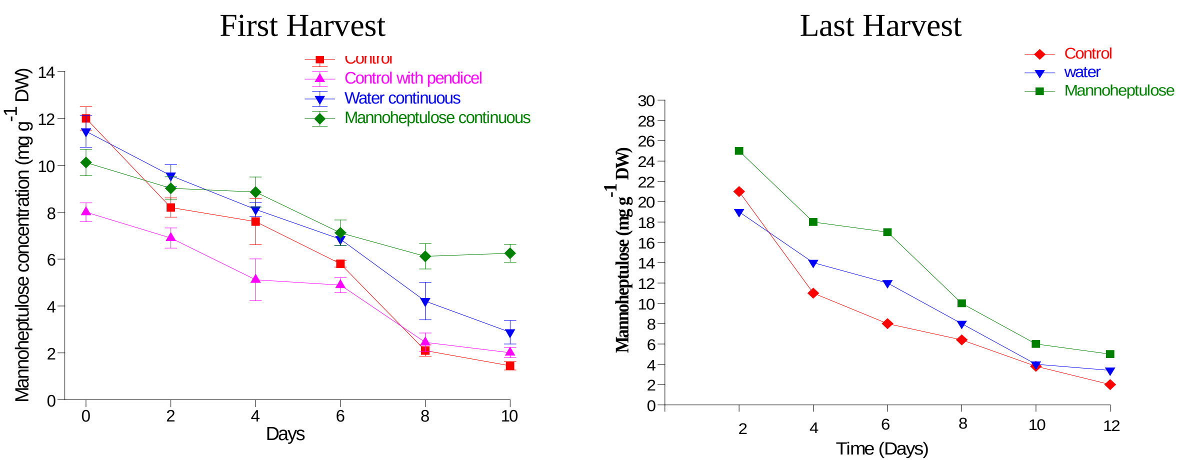

Fig. 4 Mesocarp *D*-mannoheptulose concentration of ‘Hass’ avocado fruit continuously infused with water or *D*-mannoheptulose