Avocado sugars during early fruit development

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INTRODUCTION

As primary energy storage products, sugars represent essential molecules in the life of all plants. Plants capture the energy of sunlight and transform this energy into photosynthates which are various forms of sugar molecules. Thereafter sugars are often transformed into typical storage products, like starch and various oils.

Sugars can, furthermore, serve as energy transport molecules, with sucrose as the most common form of such an energy carrier. However, a variety of other sugars have also been reported to play an important role in the metabolism of plants such as stachyose in cucurbits (Pharr *et al*., 1985). Often these sugars are sugar alcohols such as perseitol in avocado (Shaw *et al.,* 1980), sorbitol in peach (Makinen & Soderling, 1980) mannitol in apple (Makinen & Soderling, 1980) and inositol in grains (Loewus & Loewus, 1983). The exact function of these sugar alcohols is, however, unknown.

Perseitol also differs from other sugar alcohols in the number of carbon atoms in the molecule. While inositol, sorbitol and mannitol contain 6 carbons (C6 sugars), perseitol and the sugar it easily converts to, manno-heptulose, contain 7 carbons and are hence C7 sugars. Therefore, the production of these two sugars needs possibly different building blocks and follows a different pathway.

Various plant parts of avocado have been found to contain perseitol (Liu *et al.,* 2002) and it has been speculated that their role goes beyond that of a molecule simply providing carbon skeletons for proteins and oils in avocado. Not widely published Israeli research investigated the potential role of perseitol in the source-sink relationship of developing fruit and leaves and seemed to indicate that the C7 sugars play a role in the partitioning of carbohydrates during this stage of development.

As common in other sugar alcohols (Koch 1996), various parts of the avocado fruit also contain the common C6 sugars fructose and glucose. However, concentrations of such sugars are lower than those of the C7 sugars which, again, could indicate their importance, not necessary as transport sugars but as storage molecules.

In our previous research we confirmed the presence of perseitol, manno-heptulose as well as sucrose and glucose in rind, flesh and seed tissue of avocados several weeks prior to harvest (Bertling & Bower, 2005). Furthermore, the tendency towards a depleting pool of C7 sugars in 'Fuerte' fruit as harvest maturity is approached, as well as the higher flesh concentration of perseitol in 'Hass' than in 'Pinkerton' and 'Fuerte' fruit made us investigate the sugar pattern further, as the first season's results seemed to indicate the potential of these C7 sugars as markers for post-harvest quality.

We concentrated on the most important cultivar in South Africa, 'Hass', and analysed flowers, fruit as well as leaves of bearing and shy- to non-bearing trees during the early fruit development period.

MATERIALS AND METHODS

'Hass' flowers (post full bloom) and fruit were randomly collected of 20 trees of 4 rows from a commercial farm in the KwaZulu-Natal Midlands in November and December 2005. To investigate a potential difference in sugar pattern between growing fruit and dropped fruit, dropped flower / fruitlets were picked off the orchard floor. Furthermore, leaf samples (youngest physiologically mature leaf) were collected in November, December and February 2005/06 from ten bearing trees as well as ten shy- to non-bearing trees. Samples were transported to the UKZN Horticultural Physiology Laboratory. After fresh weight determination samples were shock-frozen and subsequently freeze-dried. Sample preparation was carried out as previously described (Bertling & Bower, 2005), however, for sugar separation a Rezex RCM Monosaccharide column was used as the same kind of column has been used by other researchers (Liu *et al.,* 2002).

RESULTS AND DISCUSSION

Leaves on bearing as well as non-bearing trees contained C7 sugars – with manno-heptulose dominating over perseitol – and the C6 sugars sucrose, glucose as well as fructose (**Figure 1** and **2**). Sugar concentrations between leaves varied tremen-

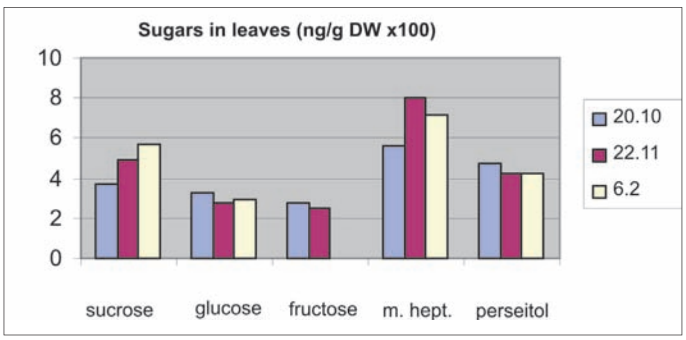

Figure 1. Sugar concentration in leaves of bearing trees.

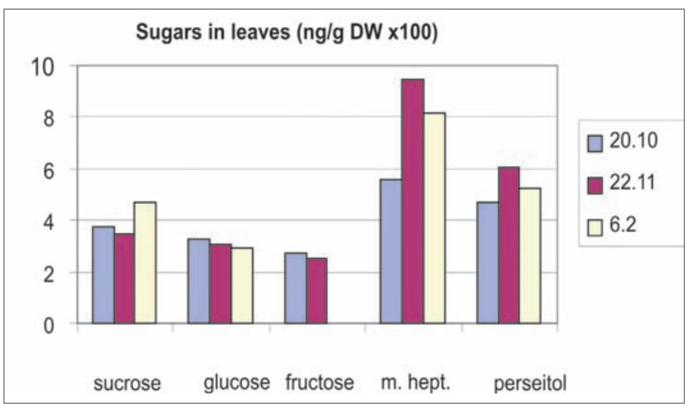

Figure 2. Sugar concentration in leaves of non-bearing trees.

dously, allowing only for the description of trends. Leaves on non-bearing trees had a tendency towards higher manno-heptulose than perseitol concentration. Furthermore, leaves on non-bearing trees seemed to have higher C7 sugar concentrations than bearing trees. This could be an indication that C7 sugars play an important role in fruit growth and development, as, seemingly, leaves cannot accumulate the same concentration of C7 sugars when the tree carries a heavier crop load.

Glucose, fructose and sucrose concentrations in the leaf tissue of bearing and non-bearing, however, did not show this difference, indicating a lesser response to fruit load than C7 sugars and confirming the postulation by Liu *et al.* that C7 sugars are more important in avocado than C6 sugars. Additionally, while the difference between manno-heptulose and the most common C6 sugar, sucrose, was two-fold in non-bearing trees, it shrunk to one third in bearing trees. This confirms the assumption that fruit are strong sinks for these particular carbohydrates.

From the September to the October sampling flowers / fruitlets showed a decrease in concentration of all five sugars identified (**Figure 3**). The C7 sugars did not dominate over the C6 sugar fructose, but sucrose and glucose concentrations were consistently lower than those of the C7 sugars. Furthermore, sugar concentrations of fruitlets which had dropped were consistently lower in than that of attached fruitlets (**Figure 4**). Particularly, the perseitol concentration had dropped to a value as low as the C6 sugars. This could indicate that fruitlet drop is related to their low C7 sugar status.

CONCLUSIONS

Our current results combined with our previous sugar pattern analysis of more mature fruit give a good indication that C7 sugars are a major player in fruit development.

It is therefore imperative to further investigate if and how the pool of C7 sugars in fruit can be increased, either by increasing the overall sugar pool size or by increasing the sugar concentration of fruit.

As sugar movements play an important role in the establishment of source-sink relationships as well as the possible subsequent alteration, methods of directing the sugar movement into fruit used in temperate fruit crops might, such as cincturing, girdling or root pruning, also possibly direct the movement of C7 sugars into developing avocado fruit.

Furthermore, if C7 sugars also play a role in source-sink relationships, certain plant growth regulators could be used to establish sink activity as they might be able direct sugar movement into the developing fruit, subsequently increasing fruit retention as well as fruit size.

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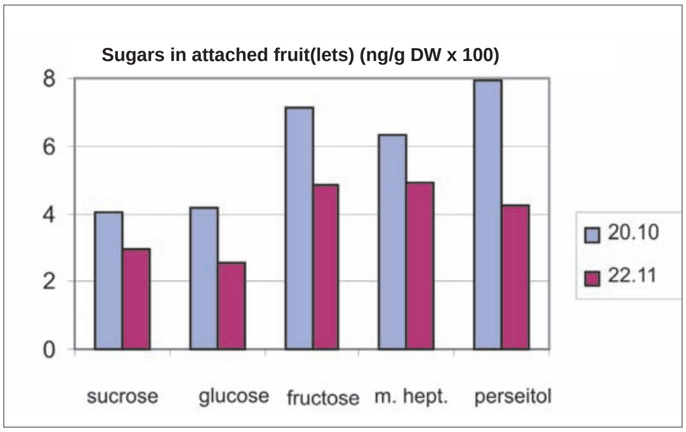

Figure 3. Sugar concentration in attached fruitlets.

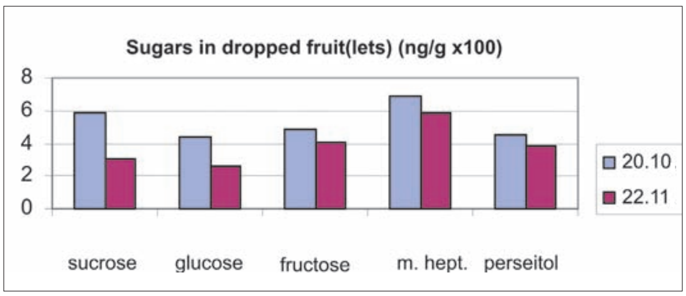

Figure 4. Sugar concentration in dropped fruitlets.