Fruit cracking – causes and prevention

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FRUIT CRACKING IS a common physiological disorder in litchi and can cause losses of up to 50-70%. Cracked fruits loose their value for the fresh fruit market and can only be used for processing. It is caused by multiple factors, including genetic background, physiological status of fruit and environmental conditions. The cracking usually occurs after a lengthy period of rain when a large amount of moisture has been absorbed by the fruit and/or after extreme temperature fluctuations. 'Early Delight' and 'Mauritius' are cracking sensitive cultivars, while 'Fay Zee Siu' and 'Wai Chee' are less prone to cracking.

Skin morphology and physiological abnormalities during early fruit development will determine cracking probability of fruit. The development of the litchi fruit is divided into two distinct growth phases. The first phase is characterised by the growth of the skin and seed, and the second phase by rapid growth of the fruit flesh. Fruit cracking occurs during the second phase of fruit development after cell division in the skin has stopped, cells begin to stretch and the fruit starts to colour up. As the growth of the skin precedes the growth of the fruit flesh, the skin determines and restricts growth of the fruit flesh. The fruit flesh that grows between the skin and the seed enlarges very rapidly during this period, exerting internal pressure on the skin which can cause the skin to crack.

The strength of the skin, i.e. the resistance of the skin against cracking, is determined by the number of cells formed during the first six weeks of fruit development, the strength of the cell walls and the thickness of the spongy tissue between the mesocarp and endocarp layers of the skin. Calcium plays an important structural role in the strength of cell walls and cell membranes. Since the litchi skin is not very strong, it is important to create optimum conditions for cell division and strong cell walls during the first fruit growth stage. Lack of water and nutrients during this period will limit cell division and cell wall strength.

The skin cracks according to an easily identifiable pattern, either a) vertically over the entire length of the fruit where too few cells were formed during early fruit development (Fig. 1) or b) horizontally or diagonally where it was damaged by sunburn or insects during the last stage of fruit development (Fig. 2).

MAIN FACTORS CONTRIBUTING TO FRUIT CRACKING

Cultivar differences

Cultivar susceptibility depends on differences in skin morphology and physiology (i.e. cracking resistant cultivars have lower tubercle density, thicker spongy tissue between mesocarp and endocarp, and better calcium mobilization within fruit). Early cultivars are more prone to cracking than late cultivars, e.g. 'Early Delight'.

Environmental factors

High temperatures (> 36°C) with low relative humidity (< 60%) as well as dry winds cause the skin to desiccate which makes it hard and inelastic, and in case of sudden moisture fluctuations causes it to crack.

Water shortage or drought during early fruit development, which limit cell division, followed by high water supply/rain during rapid fruit growth, can contribute to cracking.

Canopy position

Fruit growing on the upper and middle outer canopy area are more susceptible to cracking than fruit on the lower and inner canopy area due to greater exposure to high temperature and light intensity.

Figure 1. Fruit cracking over the entire length of the fruit due to lack of cell division during early fruit development.

Figure 2. Fruit cracking due to sunburn.

Figure 3. No fruit cracking in bagged 'Early Delight'.

Nutrition

Nutrient deficiency affects fruit development. Lack of nutrient availability or uptake (e.g. due to drought or nematode infestation) during early fruit development, especially of calcium and boron, can contribute to cracking.

Low content of exchangeable calcium in the soil can lead to low calcium

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content in the skin and therefore to reduced cell wall strength and higher cracking susceptibility.

Insect damage

Damage to the skin by pests, such as fruit fly and litchi moth, after early cell division will induce cracking during cell expansion.

Control measures

As cracking is influenced by many factors, control thereof should be approached through integrated management. The following orchard practices used in combination may reduce cracking and also help prevent sunburn:

- Optimal irrigation (at 30-40% depletion of available soil moisture) throughout flowering and fruit development, and especially during the first six weeks after female flowering.
- Irrigation early in the morning, as well as mid-canopy or overhead sprinkler irrigation to increase humidity on expected hot days.
- Mulching to maintain good moisture levels in the root zone.
- Optimal fertilisation and calcium foliar sprays during early fruit development.
- Maintaining adequate calcium levels in the soil throughout the year.
- Boron sprays (0,5%) 15 days after fruit set.
- Bagging of individual fruit bunches (to increase humidity and prevent insect damage) (Fig. 3).
- Use of shade nets (20-30%) for entire trees or orchards.
- Adequate insect control.
- Nematode control where necessary.
- Wind breaks in wind prone areas.

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Sulphur-free post-harvest treatment with salicylic acid

With sulphur fumigation, browning and decay of litchi fruit can be prevented and the fruit's shelf life extended. Due to consumer and regulatory resistance to this method, growers could benefit from sulphur-free treatments.

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LITCHI IS KNOWN for its highly perishable nature and high post-harvest losses due to skin browning and decay. Sulphur fumigation has so far been the most effective post-harvest treatment for the control of browning and decay of litchi fruit. In addition, this treatment extends shelf-life to more than 28 days, which is essential for sea freight to European markets.

However, there is increasing consumer and regulatory resistance to the use of sulfites in fresh fruits and vegetables. Although there are sulphur-free alternatives that can maintain skin colour and keep moisture loss and decay at a minimum for up to 20 days, they are only suitable for the local market or the air-freight export market which require shorter shelf-life. With new profitable export markets opening up that can be quickly supplied via air freight, but also with the local market becoming more lucrative due to expanding metropolitan cities and higher disposable income, South African growers could benefit from these sulphur-free treatments.

During the 5th International Symposium on Lychee, Longan and Other Sapindaceae Fruits in Bhagalpur, India, research on various post-harvest treatments were presented, one of them being a salicylic acid (SA) dip treatment which shows great potential as post-harvest treatment for the local market or air-freight export market of South African litchis. Salicylic acid (SA) is a natural phenolic compound. As an endogenous plant hormone it has been found to generate a wide range of metabolic and physiological responses in plants thereby affecting their growth. It plays a role in the resistance to pathogens and has also been used with beneficial results for controlling post-harvest losses of horticultural crops.

This article discusses the post-harvest treatments with SA presented at the International Symposium by Dr Alemwati Pongener and his co-workers from the ICAR-National Research Centre on Litchi in Muzaffapur, India (Pongener *et al*., 2016). The aim of the experiment was to study the possibility of combining salicylic acid with hydro-cooling as part of a litchi post-harvest management system.

The experiment was conducted on the cultivar 'Shahi', which is very similar to 'Mauritius'. SA was used at concentrations of 0.4 (55.25 mg/L), 0.8 (110.5 mg/L), and 1.2 mM (165.75 mg/L). The control fruit was treated with water only. The water temperature was kept at 10°C in order to remove the field heat from the fruit while applying the treatment (Fig. 1). The fruit was dipped for 30 minutes and therafter surface dried before packing them in perforated and unsealed polythene bags. The fruit was stored at 6°C and 80-90% relative humidity for 18 days. After 10 and 18 days storage membrane stability index, total anthocyanins content, browning index, fruit decay and TSS and acid content were measured.

Figures 2-4 show anthocyanins content, browning index and percentage fruit decay of the various SA concentrations. SA at the highest concentration (1.2 mM) was able to maintain membrane stability (data not shown) and anthocyanin content (and therefore better fruit colour), and reduced skin browning after 18 days of storage (Fig. 2 and 3). This concentration also showed the least decay (6.25%) compared to the control (43.75%) (Fig. 4). No differences in TSS and acid content were found between treatments (data not shown). 68% of SA-treated fruits were marketable.

Kumari *et al.* (2016) from the Bihar Agricultural University obtained similar results in experiments on the cultivar 'Purbi' with a 5-minute SA dip treatment (at 1.0 mM) alone or in combination with chitosan (2%). However these researchers only stored the fruit for 6 days at ambient temperatures.

Integrated with good harvesting practices (i.e. early morning picking) and adequate packaging, the SA dip treatment shows great potential as sulphur-free post-harvest treatment for litchi and should be tested for the South African local market as well as the air-freight export market.

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Figure 1. 'Shahi' litchi in a salicylic acid bath at 10°C. Source: Pongener *et al*., 2016.

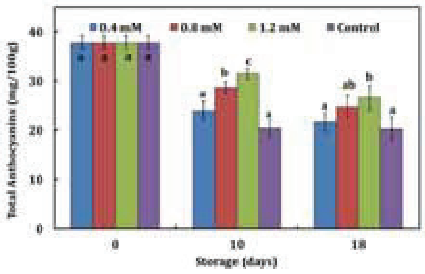

Figure 2. Total anthocyanin content in 'Shahi' litchi after various salicylic acid dip treatments after 0, 10 and 18 days of storage. Source: Pongener *et al*., 2016.

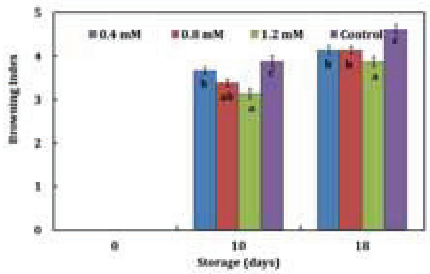

Figure 3. Pericarp browning index in 'Shahi' litchi after various salicylic acid dip treatments after 0, 10 and 18 days of storage. Source: Pongener *et al*., 2016.

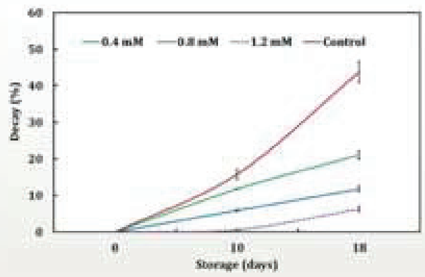

Figure 4. Percentage fruit decay in 'Shahi' litchi after various salicylic acid dip treatments after 0, 10 and 18 days of storage. Source: Pongener *et al*., 2016.