Moisture maketh the nectarine

When nectarines lose their moisture, it is not only their looks that suffer. Marketability disappears into thin air as well.

> Understanding why nectarines lose moisture will help greatly to optimise the fruit handling chain and reduce costly overseas repacking and rejections.
>
> Prof. Karen Theron

MOISTURE LOSS IS one of the main post-harvest problems of nectarines. It forces costly repacking of early-season cultivars as the fruit arrives overseas in a shrivelled state and weighing too little.

Although packaging solutions to reduce shrivel in nectarines exist, shrivel incidence remains high for most cultivars. This indicates that some moisture loss also takes place before the fruit is packed – be it pre- or post-harvest. However, it is currently not clear where the moisture-loss pressure points are in the production and handling chain.

In 2014, Hortgro Science identified investigations in how to reduce moisture loss and, hence, shrivel, as an important post-harvest research requirement. The idea was that by studying moisture loss in a more holistic manner – from when the fruit develops on the tree until it is consumed – producers could be better equipped to handle and pack nectarines in ways that prevent shrivel.

With financial support from the PHI Programme and industry, a two-year study, a two-year study was started under the leadership of Dr Mariana Jooste from Stellenbosch University's Department of Horticultural Sciences. When she left the institution, Professor Karen Theron took over the work, including supervising Kenias Chigwaya, the MSc Agric student who carried out the project.

1 Prof. Karen Theron, project leader.
2 Moisture loss is one of the main post-harvest problems of nectarines. It forces costly repacking of early-season cultivars as the fruit arrives overseas too small and in a shrivelled state.

Project objectives and rationale

According to Karen, vapour pressure deficit (VPD) and the permeability of fruit skin were the logical starting points for the research, given that VPD is the driving force for moisture loss, and that moisture loss occurs through the surface of the fruit.

Previous studies have shown that differences in the water vapour permeance ($P'H_2O$) of fruit skin are influenced by variation in the fruit's size and harvest maturity. It is also known that the deficit between the saturated vapour pressure inside the fruit and the actual vapour pressure of the surrounding atmosphere determines the fruit's rate of evaporation in the handling chain.

However, no information existed on the fruit peel $P'H_2O$ in the optimum harvest window of nectarine cultivars, and the VPD between nectarine fruit and their environment during post-harvest handling. "We needed to establish this information for nectarines produced and handled under South African conditions," says Karen. "This would give the South African nectarine industry a better understanding of when and why fruit moisture loss takes place."

The research objectives were furthermore influenced by a Hortgro Science study that found that pre-harvest potassium silicate (K_2SiO_3) applications reduced shrivel in 'Laetitia' plums. "It made sense to determine whether silicone could also control moisture loss in shrivel-prone nectarine cultivars," says Karen.

Consequently, the PHI Programme project set out to determine the following:

- The impact of fruit-to-fruit variation, harvest date, tree and orchard effects and cultivar differences on water vapour permeance of nectarine fruit;
- The weight loss and contribution of VPD to post-storage shrivel manifestation in five different handling chains between harvest and the end of cold-storage;
- The potential of pre-harvest potassium silicate applications to reduce the problem; and
- Whether different plastic packaging should be used for different fruit sizes.

All objectives contained innovative approaches.

Currently, moisture loss from nectarines is mitigated with the use of plastic packaging to increase the relative humidity around the fruit during cold-storage. However, no knowledge exists about how permeability changes as the fruit peel matures. This can greatly contribute to moisture loss even before the fruit is packed. Determining the permeability of the fruit peel at various maturation stages is an innovative way to determine the optimum harvest times for different nectarine cultivars. The result could be an easy-to-use technique that would help plant breeders to scrap or release cultivars based on their moisture-loss tendencies.

Further innovation stems from the fact that information about the VPD between nectarines and their environment will show where in the handling chain the risk for moisture loss is the highest. In response, the industry can create and apply optimum handling protocols.

The use of potassium silicate to reduce moisture loss, and hence shrivel, is also innovative, as silicate is usually employed to strengthen fruit peel cell walls against fungal attack. In this study, silicate's properties were used in an attempt to reduce the incidence of hairline cracks and shrivel, and to make the cell walls of the fruit stone more elastic. The latter should reduce the incidence of split stones.

Currently the same packaging is used for small and large fruit sizes, despite smaller fruit being more prone to moisture loss during storage. This study adopted a novel approach by comparing larger and smaller fruit sizes and packaging to determine optimum internal packaging for each size.

How the work was done

For objective 1, five farms were selected for a field trial to determine the skin $P'H_2O$ differences between a cultivar susceptible to moisture loss ('Alpine') and two less susceptible cultivars ('Mayglo' and 'August Red'). Permeability was measured from four weeks prior to harvest until post-optimum maturity.

For objective 2, a trial was set up on a commercial farm, using 'August Red', to establish which handling chains posed the highest risk for moisture loss, and at which point the moisture loss risk was the highest within each handling chain.

For objective 3, a trial was set up on a commercial farm, using 'Crimson Glo', a cultivar susceptible to shrivel and split stones. Potassium silicate was applied as both a foliar spray and a root drench. After harvesting, the fruit was stored and then analysed.

PROJECT TITLE
Moisture loss in nectarines

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DURATION
Two and a half years

PHI PROGRAMME & INDUSTRY CONTRIBUTIONS
R605 016 & R455 016

LEAD INSTITUTION
Stellenbosch University (Department of Horticultural Sciences) and Hortgro Science

BENEFICIARY
The South African stone fruit industry

FOCUS AREA
Post-harvest physiology, and temperature and humidity control

HUMAN CAPITAL DEVELOPMENT
One MSc Agric student

PUBLICATIONS
One

PRESENTATIONS AND PAPERS
Three

For objective 4, samples of 'August Red' packed in four different packaging types, were drawn from a commercial packhouse on the harvest date.

Randomised complete block designs were used to establish fruit peel permeabilities and for the silicate trial. Complete randomised designs were used in the VPD and packaging trials.

In all cases, the trials were repeated in two consecutive seasons in order to verify the results of the various fruit evaluations that were conducted.

The outcomes

The study showed that large fruit-to fruit-differences were the main contributor to the variation in P'H_2O, followed by harvest date, cultivar differences and orchard effects. Tree effects did not contribute to P'H_2O.

Generally, the P'H_2O of all three cultivars increased steadily as the harvest date approached and continued to increase post-harvest. However, P'H_2O at optimum harvest was not closely correlated to the fruit's susceptibility to shrivel.

'August Red' nectarines were exposed to different handling chains from harvest until the end of shelf life. The results indicated that none of the proposed handling chains performed better than the current standard handling protocol in reducing moisture loss and shrivel. This protocol stipulates that nectarines should be harvested during the cooler time of the day and field heat should be removed as soon as possible after harvesting. Nectarines should also not be allowed to stand at elevated temperatures or low relative humidity, and should be packed and placed under cooling within six hours after harvest.

The researchers furthermore recommended that producers apply measures to ensure a more even maturity of fruit on the tree, and use non-destructive measures to sort fruit post-harvest so that maturities in cartons will be more even. When all the nectarines in a carton are more or less equally mature, producers can make better decisions about internal packaging and marketing destinations.

The results showed that the use of Xtend® and high-density polyethylene (HDPE) bags significantly reduced moisture loss and shrivel in nectarines in both pulp trays and plastic punnets. The standard nectarine HDPE wrappers resulted in significantly higher percentage mass loss as well as shrivel incidence in 'Alpine' nectarines. HDPE bags and Xtend® bags controlled moisture loss significantly better than shrivel sheets in 'August Red' nectarines, but cannot be recommended as the internal quality of the fruit was compromised.

Neither soil nor foliar silicate applications were effective in reducing post-harvest moisture loss, shrivel or the incidence of split pit in 'Southern Glo' nectarines. For future studies, it is recommended to increase the frequency of K_2SiO_3 applications.

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2 MSc student, Kenias Chigwaya, measuring the firmness of nectarines, using a fruit texture analyser, after four weeks of cold-storage at -0,5°C and five days of shelf life at 10°C.

MOISTURE LOSS IS A FACT OF LIFE

Moisture loss is a cumulative process that starts as soon as fruit is picked. It is a serious problem that affects quality characteristics such as appearance and saleable weight. In addition, many harmful physiological processes are triggered by moisture loss. Therefore, to extend the shelf life of fruit, its rate of water loss must be as low as possible.

Moisture loss and quality control start by determining optimum harvest maturity, given that fruit of post-optimum maturity is much more prone to post-harvest moisture loss.

Fruit starts losing quality and freshness from the moment it is picked, hence the cooling process has to start as quickly as possible. Effectively moving the fruit from the orchard to the cooling facility has a far greater impact on quality than even the most expensive cooling infrastructure.

In areas where daytime temperatures are high, such as the Klein Karoo, producers harvest early in the morning. Once picked, the fruit is packed in crates or bins and placed in shady areas in the orchard until taken to the packhouse. Some producers line the bins with plastic and, once filled, cover the fruit with damp blankets. These precautions prevent exposure to direct sunlight, moisture loss and dust settling on the fruit.

Packhouses should ideally receive the fruit in a cool, permanently shaded area. The fruit should be off-loaded quickly and carefully within 30 minutes after arrival and immediately placed in the pre-cooling room.

Once the field heat has been removed, the fruit is moved from the pre-cooler straight into the packhouse where it is graded and packed. It is important to carefully sort the fruit according to maturity and injuries on the packline. Over-mature and injured fruit are much more prone to lose moisture, resulting in shrivel, and to arrive under-weight at the destination.

Not paying attention to this important detail causes sound fruit to be unnecessarily rejected at the market due to the presence of one or more over-mature and/or injured fruit in a carton.

Well-ventilated packaging material that provides the fruit with the necessary support and protection is hugely important when it comes to rapid and effective cooling, gas exchange and the prevention of anaerobiosis.

Maintaining the nectarine cold chain is not a case of setting the thermostat and closing the door of the cold store or reefer container. It is an art as much as a science, and requires the careful balancing of temperature, humidity and air flow with the fruit's natural metabolic processes and human activities in the supply chain.

Temperature and humidity greatly affect the rate at which evaporation takes place. The difference in temperature between the fruit and the environment is the main reason for the vapour pressure difference that dehydrates fruit.

Fresh fruit has a fixed store of energy that helps it to survive post-harvest. Respiration is the chemical process by which fresh produce convert sugars and oxygen into carbon dioxide, water, energy and heat to drive all its metabolic processes. According to research, up to 30% of energy released by the respiration process is released as heat which increases the temperature of the fruit. This, in turn, increases the water vapour pressure just below the surface of the fruit, leading to increased moisture loss. It is this heat that has to be managed away from the fruit without allowing it to dehydrate.

Due to their climacteric nature, nectarines ripen after harvest and therefore have a high rate of respiration that will increase at higher temperatures.

The importance of having a well-designed, well-managed refrigerated storage facility, using well-designed packaging and adhering to cold chain protocol, cannot be over-emphasised.

Once filled with fruit, the bins are covered with damp blankets to prevent exposure to direct sunlight, moisture loss and dust settling on the fruit.