# In-depth solution to superficial scald

Controlling superficial scald can be as simple as breathing: the secret lies in striking the right balance between $O_2$ and $CO_2$.

**1** The research team members are (from left) Howard Ruiters, technical assistant; Tatenda Kawhena, MSc student; Vanessa Fortuin, technical assistant; and Anél Botes, project leader.
**2** To determine the role of alcohol in the control of superficial scald, project leader, Anél Botes, measures alcohol levels after each low oxygen stress period.

**SUPERFICIAL SCALD IS** a post-harvest physiological disorder that seriously limits the storage life of a number of apple and pear cultivars.

The post-harvest chemical diphenylamine (DPA) has been used widely in the South African pome fruit industry since the 1960s to control superficial scald. Despite being an effective treatment, it was not without controversy. DPA was initially developed to keep rubber stable and, given that its derivatives are still used as protective agents in the manufacture of rubber products, it was suspected of not being entirely safe for human consumption.

As far back as 2008, the Agricultural Research Council (ARC) Infruitec-Nietvoorbij, supported by Hortgro Science, proactively started researching alternative post-harvest treatments and new cold-storage protocols to control superficial scald on specific pear and apple cultivars.

In 2012, PHI-2 provided further funding to test the use of dynamic controlled atmosphere (DCA) storage in this regard. Although results showed that DCA-stored fruit had better fruit firmness, skin colour, appearance, taste and texture than controlled atmosphere (CA) treated fruit, it was also found that some of the economically important cultivars, notably 'Packham's Triumph' pears, lost their firmness faster while on the shelf. This problem was solved through the application of SmartFresh™.

Acting on consumer concerns, the European Union lowered the maximum residue limit (MRL) allowed for DPA to 0,1ppm for both apples and pears in March 2014. This development, which resulted in a MRL value that is all but impossible to achieve, prompted the local pome industry to accelerate the search for alternatives in order to maintain its biggest and most lucrative market.

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## WHAT IS SUPERFICIAL SCALD?

Low storage temperatures of between -0,5°C and 0°C maintain fruit quality for extended periods. However, once taken out of cold-storage and placed on display at 17°C to 20°C, the fruit skins can break out in irregular brown or black patches within hours.

Superficial scald, as this is known, is caused by the auto-oxidation of alpha-farnesene, a volatile in the coating of pears and apples responsible for the fruits' characteristic smell.

When apples and pears are exposed to higher temperatures after long-term cold-storage, alpha-farnesene breaks down to form the volatile 6-methyl-5-hepten-2-one (MHO), inducing scald-like symptoms.

## Finding new answers

A two-and-a half-year study, jointly financed by Hortgro Science and the Post-Harvest Innovation Programme, started to investigate non-chemical storage technologies that can prevent superficial scald in apples and pears in January 2015. The technologies under the microscope were DCA-CF (dynamic controlled atmosphere – chlorophyll fluorescence) and repeated low oxygen stress (RLOS) in combination with ultra-low oxygen (ULO) and CA. Although RLOS had been used commercially elsewhere in the world, the technology had not been applied to fruit grown under South African conditions.

"We knew the technologies controlled superficial scald," says project leader, Anél Botes, a researcher at the Post-harvest and Wine Technology Division of ARC Infruitec-Nietvoorbij. "But we did not know what their impact would be on locally produced fruit, and on fruit quality during long voyages, given that South Africa is much further away from its markets than the European countries where the technologies were developed."

Working with Anél on the project were Tatenda Kawhena, an MSc student in Horticultural Science, and Asanda Mditshwa, a PhD student. Collaborating institutions were Stellenbosch University with Prof. Linus Opara, and Laimburg Experiment Station in Italy.

## Aim and objectives

The aim of the study was to investigate the effects that various long-term dynamic controlled atmosphere technologies would have on South African grown 'Granny Smith' apples and 'Packham's Triumph' pears in the context of preventing superficial scald while ensuring fruit quality and a longer shelf life.

Specific objectives included the development of storage protocols for CA stores to prevent superficial scald on 'Granny Smith' apples and 'Packham's Triumph' pears during long-term storage.

Anél explains that all the storage

## RLOS EXPLAINED

Repeated low oxygen stress (RLOS) is a storage protocol for apples and pears that involves a significant reduction in oxygen at monthly intervals during the storage period. The stress that is thus created in the form of alcohol production seems to be an effective method for preventing superficial scald. The RLOS protocol is followed with ultra-low oxygen storage.

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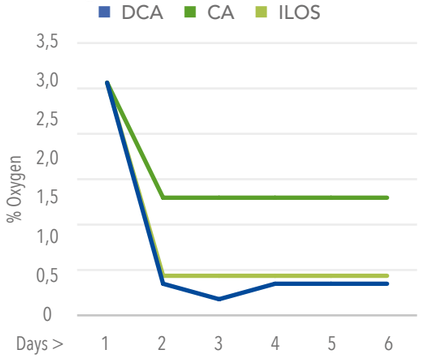
**Figure 1: DCA-CF, CA & ILOS**




Oxygen concentration achieved after DCA-CF, CA and ILOS technology are applied after harvest.

**PROJECT TITLE**
Non-chemical storage technologies for apple and pear superficial scald prevention

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**DURATION**
Two years and six months

**PHI PROGRAMME & INDUSTRY CONTRIBUTIONS**
R 1 042 430 & R842 430

**LEAD INSTITUTION**
ARC Infruitec-Nietvoorbij

**BENEFICIARY**
The South African pome industry

**FOCUS AREAS**
Container and cold-storage technology, and post-harvest physiology

**HUMAN CAPITAL DEVELOPMENT**
One PhD student and one MSc Agric student

**PUBLICATIONS**
Three

**PRESENTATIONS AND PAPERS**
Four

> The exciting thing about this project is that RLOS gives us a possible alternative to DPA; it can be another tool in our toolbox in the quest to prevent superficial scald.
>
> Anél Botes

**1** Tatenda Kawhena in the laboratory, busy with the biochemical analyses for the 'Granny Smith' apples and 'Packham's Triumph' pear trials as part of his MSc thesis.
**2&3** 'Packham's Triumph' pears (**2**) and 'Granny Smith' apples (**3**) show severe superficial scald symptoms after seven months storage in RA at -0,5°C and 0°C, respectively.

technologies included in the project are appealing because they

- are non-chemical;
- use CA technology that is already in use at all fruit packhouses;
- extend the storage time of fruit; and
- control superficial scald and other storage disorders.

"The application of techniques such as RLOS and ULO within a CA cold store can be a more economical/cost saving alternative for superficial scald control than DCA-CF storage," says Anél. "However, to compare the efficacy of these storage techniques for different cultivars, we had to test them for various storage periods over two seasons."

## Methodology

'Granny Smith' apples were harvested at two maturities and subjected to four treatments (RLOS+ULO-CA; RLOS+CA; DCA and RA).

The same treatments, except for the DCA, were applied to optimum harvested 'Packham's Triumph' pears.

The monitoring of ethanol after each stress period is crucial to this technology.

After each shelf-life period, the apples and pears were evaluated for sensory attributes by scoring visual appearance, taste and texture, as well as physiological disorders, which included superficial scald incidence.

## Results and conclusions

In the first season, RLOS+ULO-CA, RLOS+CA and DCA were effective in preventing superficial scald on pre-optimum and optimum 'Granny Smith' apples for a storage period of up to 10 months with a seven-day shelf life. Core flush emerged as a problem for the longer storage periods.

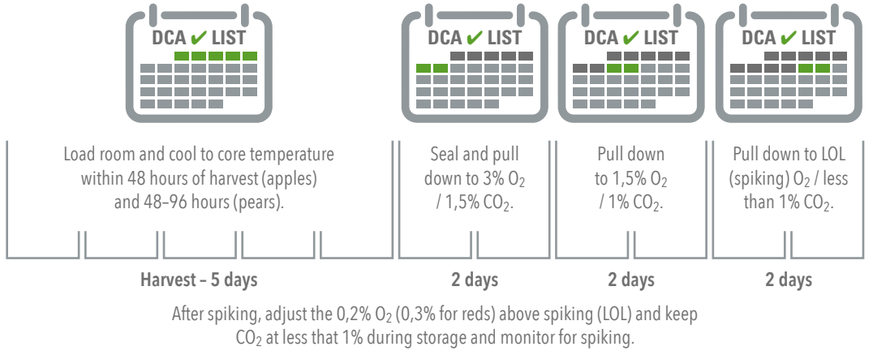
In the second season, superficial scald was observed for both maturities on RLOS+ULO-CA and RLOS+CA, and also on the optimum 'Granny Smith' DCA fruit, after a six-month storage period. Evaluation of the second season data is still ongoing.

All treatments resulted in firmer fruit and better skin colour retention.

In both seasons, RLOS+ULO-CA and RLOS+CA were effective in preventing superficial scald on optimum 'Packham's Triumph' for storage periods of up to 10 months followed by a 14-day shelf life.

In the first season, all treatments resulted in firmer fruit with better skin colour retention, and no off-tastes were detected.

**Figure 2: DCA protocol for apples and pears**




After spiking, adjust the 0,2% $O_2$ (0,3% for reds) above spiking (LOL) and keep $CO_2$ at less that 1% during storage and monitor for spiking.

## THE DYNAMICS OF COLD-STORAGE

Successful cold-storage depends on controlling the levels of oxygen that the fruit is exposed to. In general, the lower the oxygen concentration, the longer the fruit can be stored. However, when the oxygen concentration drops too low, fermentation will start.

Oxygen concentrations of slightly over 1% are usually regarded as safe for the long-term storage of fresh fruit.

Controlled atmosphere (CA) and dynamic controlled atmosphere (DCA) storage are similar in that both maintain quality by storing products in a gas-tight room that controls temperature, oxygen and carbon dioxide concentrations, and relative humidity.

Certain DCA technology uses fluorescence detection sensors to dynamically control the atmosphere. The sensors measure the amount of fluorescence light emitted by the fruit's skin, allowing operators to pin-point the anaerobic point.

Simply put, the pears' "breathing" tells the operator when and by how much to reduce the oxygen levels in the storage rooms to maintain optimum storage conditions that preserve fruit quality without causing superficial scald.

DCA sounds like the perfect solution – except that it is expensive.

Fortunately all fruit packhouses in South Africa already use CA cold-storage, a technology that can be manually adapted to achieve a variety of alternative dynamic atmosphere storage regimes, such as RLOS, ILOS and ULO-CA, at a much lower cost than DCA.

The downside is that manual adaptation can be challenging to master. As each cultivar requires unique settings, operators of CA storage facilities have to undergo training to correctly interpret the information provided by the chlorophyll fluorescence measurements.