Green Chemistry

There is life after DPA

Technology that monitors the oxygen levels in pears is a breath of fresh air in the quest to prevent superficial scald without the use of chemicals.

THE POST-HARVEST CHEMICAL, Diphenylamine (DPA), has been used widely in the South African pome fruit industry since the 1960s to control the skin condition called superficial scald.

It has been the only control measure to be applied on 'Packham's Triumph' pears and apple varieties such as 'Granny Smith', 'Red Delicious', 'Cripps Pink', 'Cripps Red' and 'Golden Delicious'. Its anti-scald activity is the result of its antioxidant properties, which prevents the oxidation of alpha-farnesene (involved in the development of superficial scald in fruit) to MHO (6-methyl-5-hepten-2-one), and the subsequent development of brown skin discolouration during storage.

A recent change in European Union (EU) regulations now allows only minimum traces of DPA on export fruit. From March 2014, the maximum residue limit (MRL) allowed for DPA is 0,1ppm for both apples and pears destined for export to EU markets.

This is part of the EU's drive to eliminate all post-harvest synthetic chemical treatments on imports, due to health and environmental risks. The anti-DPA stance is understandable, given that it was initially developed to keep rubber stable, and its derivatives are still used as anti-ozonantsor protective agents in the manufacture of rubber products.

When discussions on possible new regulations for DPA use started, South African apple and pear exporters had to re-look their export strategies. An option was to find markets other than Europe or Russia for their produce, but since 60% of all pears grown in South Africa are exported to these destinations, it was clearly not the preferred option. The alternative was to explore replacements for DPA, so that these lucrative markets can still be accessed without fear of produce being turned away at customs.

As far back as 2008, the Agricultural Research Council (ARC) Infruitec-Nietvoorbij started developing strategies to find alternative ways of preventing scald. Kobus van der Merwe led the project, supported by HORTGRO Science.

Dynamic Controlled Atmosphere (DCA) storage technology emerged as an appealing option, because it is non-chemical and uses existing controlled atmosphere (CA) technology. The Post-Harvest Innovation Programme provided further funding to draw purposeful conclusions on what the minimum exposure period is in the use of DCA to control superficial scald on pears.

Dr Filicity Vries, a senior researcher in the Post-harvest and Wine Technology Division of ARC Infruitec-Nietvoorbij, leads the project with the assistance of Mr Van der Merwe. Prof. Linus Opara, South African Chair in Post-harvest Technology at Stellenbosch University (SU), Dr Elke Crouch of the SU Department of Horticultural Science, and an MSc student in Horticultural Science at SU, Melrose Ramokonyane, are collaborating on the project.

The team members set out to investigate the effectiveness of DCA fluorescence-based technology to reduce the development of superficial scald during long-term storage and to maintain post-harvest pear quality and shelf life.

1 Pears stored in dynamic controlled atmosphere remain firm and are deliciously tasty and fragrant once ripe.
2-3 Pears with scald and without scald.

CA VERSUS DCA

"The main thing we are controlling is the oxygen levels in existing CA rooms," explains Ms Ramokonyane, who is in the process of writing up the results of the studies for her MSc thesis.

She says that DCA and CA storage are similar, in that both maintain quality by storing products in a gas-tight container that controls temperature, oxygen and carbon dioxide concentration and relative humidity.

DCA technology uses fluorescence detection sensors to dynamically control the atmosphere. It makes the storage of fruit at its lowest respiration rate possible. The sensors measure the amount of fluorescence light emitted by the fruit's skin, allowing operators to pin-point the anaerobic point. This is an essential parameter in determining the minimum level of oxygen to be maintained in the room during storage. "Simply put, the pears' 'breathing' tells the operator when and by how much to reduce the oxygen levels in the storage rooms to preserve fruit quality without causing superficial scald," says Ms Ramokonyane.

With DCA, it is possible to create ideal conditions for the medium to long-term storage of fruit, as it allows the operator to lower the oxygen levels in storage rooms without the risk of hypoxia and correlated physiological disorders. It is thus possible to set and adapt the values of gases in a dynamic manner, based on the maturity, climatic variations, different origins and varying respiration rhythms of the monitored fruit.

WHAT IS SUPERFICIAL SCALD?

Superficial scald, also known as storage scald, is a physiological disorder of apples and pears. Scald appears as irregular brown discolouration of the skin of the fruit, severely affecting the external appearance. This can reduce the acceptability of the produce for the fresh fruit market. Symptoms develop after cold storage during the shelf life period.
Source: Washington State University

PROJECT TITLE
Dynamic Controlled Atmosphere (DCA) as a practical technology

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DURATION
One year

PHI-2 CONTRIBUTION
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LEAD INSTITUTION
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BENEFICIARY
The deciduous fruit industry

FOCUS AREA
Green chemistry

HUMAN CAPITAL DEVELOPMENT
One MSc student

PUBLICATIONS AND PRESENTATIONS
Three

> "The main thing we are controlling is the oxygen levels in existing controlled atmosphere rooms."
>
> Melrose Ramokonyane

CONDUCTING THE RESEARCH

The research was done in the DCA storage facilities of ARC Infruitec-Nietvoorbij in Stellenbosch. 'Packhams Triumph' and 'Forelle' pears from the Grabouw and Ceres production areas in the Western Cape were harvested at optimal maturity and subjected to storage at:

- CA ('Packham's Triumph' 1,5%O_2/2,5%CO_2; 'Forelle' 1,5%O_2/0-1%CO_2);
- DCA ('Packham's Triumph' DCA + 1%CO_2; 'Forelle' DCA + 0-1%CO_2); and
- Regular air (RA) (control).

The storage regimes were tested for four, six and eight months. The next stage was a four-week RA (shipment period) for the CA and DCA fruit, followed by a shelf life period of zero, seven and 14 days at 20°C. Quality evaluations were conducted after zero, seven and 14 days for each treatment according to industry standards. The experimental layout was a completely randomised design with a factorial layout. The factors included two areas, two storage regimes, three storage periods and three shelf life periods.

THE RESEARCH RESULTS

The research has led to key findings that can be put into practice by pack houses:

- DCA technology effectively inhibits superficial scald on pears for up to eight months in storage.
- It maintains the post-harvest quality of the fruit through increased firmness retention and better skin colour retention at shelf life conditions.
- DCA-treated pears can only be kept on the shelf for up to seven days.
- DCA inhibits scald by suppressing the oxidation of alpha-farnesene to MHO.

MAINTAINING A COMPETITIVE EDGE

"DCA technology extends the storage life of pears for up to eight months and it effectively inhibits superficial scald on 'Packham's Triumph' pears," summarises Dr Vries. "It is a cost-effective alternative as producers and exporters only have to install the DCA software to continue using existing CA rooms."

DCA technology helps fruit from South Africa to retain its quality and it prevents superficial scald development. As a result, South Africa can maintain its competitiveness on the global market."

> "This technology helps fruit to retain its quality and prevents superficial scald development, which helps South Africa to maintain its competitiveness in the global market."
>
> Dr Filicity Vries

SHARING KNOWLEDGE

The European Union's decision to lower the permitted residue level of DPA for export pears has sparked efforts to find alternative post-harvest treatments and to develop new storage technologies.

At ARC Infruitec-Nietvoorbij, the search for new alternatives for the prevention of superficial scald has led to the testing of a cold storage technique called dynamic controlled atmosphere (DCA)

This technology will give the South African pome fruit industry a competitive edge by effectively reducing the use of DPA. Courtesy of DCA storage, it will be possible to store pears for extended periods without the development of any disorders. The resultant increase in fruit quality and extended shelf life, will help the local industry to maintain a competitive position in the global marketplace and remain a significant player in international trade

To transfer this new-found knowledge, reports will be presented at industry meetings and published in peer-reviewed scientific journals.

1 The research team members are (from left) Kobus van der Merwe, Vanessa Fortuin, Melrose Ramokonyane, Howard Ruiters and Dr Filicity Vries.
2 CA vs DCA: 'Forelle' pears benefit greatly from being stored in dynamic controlled atmosphere (DCA). The ripening process is inhibited (pear on the right) and shelf life is prolonged compared to the pear on the left that was stored in a controlled atmosphere (CA).
3 Melrose Ramokonyane shows the fluorescence technology that monitors the pears' oxygen concentration level and triggers an alarm when it reaches the point where anaerobic fermentation begins. Urged by the pears themselves, the operator then adjusts the temperature to inhibit ripening.