ANTIOXIDANT USE IN APPLE AND PEAR STORAGE

PART 2 – ALTERNATIVES TO ANTIOXIDANTS

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This article is Part 2 of the international survey which compiled the answers regarding the use of 1-MCP on apples and pears. See Part 1 and Part 3 for more information.

ALTERNATIVES TO ANTIOXIDANTS

In recent years increasing interest in health and the environment has stimulated studies of alternatives to the usual procedures for controlling pests and diseases. The fact that antioxidants are applied after harvest on fruit generally consumed fresh subjects them to close scrutiny. Therefore it is imperative to find dependable alternatives for scald control in apples and pears.

Alternative systems under study can be classified into physical and chemical.

Physical methods include modified and controlled atmospheres, heat treatment, hot water treatment and holding fruit at temperatures above 30 °C (curing). Other physical treatments that have been studied are ionizing radiation and the application of ultraviolet light.

Chemicals that have a very low toxicity, such as essential oils, ozone, ethanol vapors, methyl jasmonate and 1-methlycyclopropene (1-MCP) are also being evaluated.

Current potential postharvest treatments to control scald under research and development include:

- Dynamic controlled atmosphere (DCA), which utilizes fluorescence or ethanol accumulation to determine set point of oxygen (O_2)
- Application of vegetable oils
- Treatment of ethanol vapor
- Hypobaric storage (storage with a pressure lower than atmospheric)
- Heat treatment pre- storage
- Intermittent warming during storage
- Initial high carbon dioxide (CO_2) stress
- Initial low oxygen stress (ILOS)
- Controlled atmosphere (CA)
- Application of 1-MCP (see Part 3 of this paper)

All of these treatments have shown some efficacy in laboratory studies but the results on a commercial scale and the cost/benefit ratios are as yet unknown.

Below is a summary of the alternatives mentioned by researchers consulted in the survey and their use on a commercial scale.

Controlled Atmosphere Strategies to Control Scald

Researchers in *Australia,* think that ultra-low oxygen (ULO) and ILOS storage are the alternatives that have greatest potential, using chlorophyll fluorescence (Harvest Watch) to ensure the absence of anaerobiosis.

Researchers in *Brazil* are looking at low O_2 CA, especially ILOS, for apples and possibly on pears. They caution that respiration must be monitored by chlorophyll fluorescence (Harvest Watch), ethanol production or the respiratory quotient (O_2 consumed/CO_2 produced) and are testing these methods in 'Gala' and 'Fuji' apples.

Commercial packinghouses in British Columbia *Canada* have successfully used low O_2 (0.7%) for scald control on 'Delicious' for many years. However, no one has adopted DCA (specifically Harvest Watch) due to the perceived risk for little additional benefit.

Researchers in *Chile* have been promoting the use of the DCA, but the technology has its limitations especially under conditions in which fruit of vastly different quality are stored in the same room. They consider it a technology that should be further evaluated.

Researchers in *Israel* have begun to assess DCA (using HarvestWatch). Last season they had good results with 'Granny Smith' and 'Starking Delicious' apples and this season have included 'Spadone' pears in the test, but have not yet evaluated the fruit. In apples they have compared DCA with 1-MCP; CA has been successful, but scald control is not always 100%, so growers also use antioxidants. They believe that low oxygen alone is not enough to maintain apple quality. Israeli researchers have developed a procedure that could replace DPA and 1-MCP. The principle is pretreatment with low oxygen for 7 to 10 days at 20 °C prior storage in air at 0 °C (Pesis et al., 2007). The protocol is not easy to use; however this method has been successful in controlling scald and bitter pit, as well as maintaining firmness and freshness comparable with 1-MCP in both apples and pears. It has not been commercialized as yet, but they plan to do a semi-commercial experiment this year.

In Europe, *Italian* researchers suggest that early and mid-harvested 'Williams' pears can be stored under low O_2 (1 to 1.5% O_2 + 1 to 3% CO_2) without developing storage scald. However the sensitivity of a specific lot of pears to low O_2 must be assessed prior to commercial use. They are also evaluating DCA on 'Conference' pears but do not have final results yet. They are comparing DCA and Super ILOS although some scald has developed in 'Abate Fetel' with these methods. They also consider that DCA could be combined with 1-MCP, depending on the quality of fruit. DCA technology now is being used in apple production areas of *Germany*. DCA has been successfully tested in laboratory experiments with 'Williams', 'Anjou', 'Forelle', 'Packham's Triumph' and 'Spadone' pears (USA, Canada, South Africa, Israel).

Researchers in the *Netherlands* think that DCA, DCS (a variant of the DCA, based on the measurement of ethanol), ULO and ILOS are the only sustainable technologies to replace DPA. CA can be an alternative for pears but nitrogen (N_2) should be applied regularly to flush out α-farnesene.

Researchers in *South Africa* recommend CA or ULO) storage since the fruit is less susceptible to scald than in regular storage, but scald is not completely inhibited. ILOS storage followed by CA can inhibit scald up to 8 months in 'Granny Smith' and 'Red Delicious' apples. In DCA trials, they found that superficial scald was completely inhibited in 'Granny Smith' and 'Red Delicious' apples and 'Packham's Triumph' pears stored for 9 months, followed by a shelf life of 7 days at

20 °C. Yet South Africa currently has no commercial facilities using DCA because this technology is still being evaluated.

Researchers in the *United States* are investigating the effects of late harvest and very low O_2 levels combined with high levels of CO_2. Initial low O_2 stress (near zero ILOS) for a couple of weeks followed by low O_2 has been used successfully on apples. A commercial storage operator reported success in delaying scald development on 'Granny Smith' and 'Red Delicious' organic apples with DCA. However, low O_2 damage has been observed with increased volumes and in other varieties. They question whether the benefits outweigh the risks. In Washington State last season there was a report that several rooms have had problems using DCA (*The Grower*, February 2010). DCA is being used commercially in five major packinghouses in Washington. Scald control without DPA will be easier on apples than on pears. In pears, ILOS has reduced scald but there are risks of damage to the fruit. DCA or ILOS with 'Beurre D'Anjou' pears has been successful in controlling scald but has led to internal disorders (browning, cavitation) and stem end (external) browning. In some cases scald has developed when the low O_2 concentration set point of DCA was allowed to rise to levels used a typical CA room.

Ethylene Removal

A commercial facility in *Portugal* is building new CA rooms which will introduce a new management system that employs CA and low levels of ethylene.

In the *United States,* a new system of ethylene removal is being evaluated, which in theory would be more effective than Purafil. A commercial trial on 'Bramley' apples stored in CA compared an ethylene removal system (Bi On-4, which contains zeolite clay pellets impregnated with potassium permanganate) with 1-MCP application for scald control. The results showed that the efficiency of ethylene removal system was comparable to 1-MCP, and there was no CO_2 damage. The system also reduced the incidence of decay. It is an effective system in relation to cost and is suitable for storage combined with low O_2.

Resistant Varieties

Researchers from *Australia, South Africa* and the *United States* consider that the long-term solution is to grow varieties resistant to scald. However plant breeding is a long-term solution and many of the current scald-susceptible varieties have desirable commercial attributes.

Inhibition of Phospholipase D

Phospholipase D is a key enzyme involved in initiation of membrane deterioration. Inhibition of its activity prevents the destabilization of the membranes and increases the longevity of the products (Paliyath and Subramanian, 2008). At the University of Guelph in *Canada*, scientists have been successful using phospholipase D inhibition technology to control scald in apples. Hexanal-based treatments (potent inhibitors of the activity of this enzyme) are easy to perform, effective and may even be compatible with organic production.

Combined Strategies

Researchers in *Portugal* are considering a combination of treatments for scald control: a new product combined with CA. In conventional storage (regular air) it will not be easy to control scald.

Researchers in *Spain* consider that combined strategies should be used and antioxidant dosage might then be reduced by 4 to 10 parts. These strategies could include: pre-conditioning (heat

pretreatment), ethanol vapors, methyl jasmonate or similar treatments. In pears there is the possibility of extracting a natural antioxidant from the peel, because the concentration of antioxidants is high. In apples, methods could include reducing the temperature gradually to achieve CA or delaying the generation of CA.

Other Antioxidants

In *Chile* there are some commercial alternative antioxidants being evaluated but the trials do not show consistent results and could generate other physiological disorders.

Integrated Management

Researchers in *Chile* remind growers of the importance of proper orchard management (e.g., maturity at harvest) and balanced fruit nutrition. Fruit segregation upon receipt is critical to selecting the most effective management according to the needs of each lot of fruit. The fruit should not be stored for longer than its potential and should be closely monitored in storage.

South Africa recommends harvesting susceptible cultivars at optimum maturity or slightly post-optimal to reduce the risk of scald. Fruit harvested early or harvested in hot weather conditions are more susceptible to scald. Fruit stored at elevated temperatures such as at 1 °C developed less scald than fruit stored at -0.5 °C.

In the *United States*, management practices in the orchard and in the packinghouse are imperative especially for organic producers who have no tools to control physiological disorders. These include: appropriate cultural practices, harvesting at the right time, monitoring maturity parameters, and storing under optimal conditions (temperature, O_2 and CO_2 levels for each variety).