Understanding Flesh Browning in Pink Lady Apples

Dr Jenny Jobling*

There has been a lot of concern in recent years about the flesh browning disorder of Pink Lady apples. To date there is a lot of anecdotal evidence for causes of the problem but little scientific data. This is soon to change as a result of a large Horticulture Australia Limited (HAL) project that began in July 2002.

The HAL project is a large collaborative effort with several groups from around the world are participating. Each group has its own area of expertise which means that the project can address much of the anecdotal evidence at one time. The other benefit is the counter season work done in the USA means that we can effectively have 2 seasons worth of data in one year.

The project collaborators are Jenny Jobling (Project Leader), Sydney Postharvest Laboratory, David Tanner from Food Science Australia, Ian Wilkinson, IHD Knoxfield, Gordon Brown, Scientific Horticulture, Tasmania, Stuart Tustin, HortResearch, New Zealand and Beth Mitcham, University of California, USA. The Californian harvest season for Pink Lady apples begins in October 2002 and so we look forward to some preliminary results early next year.

The aim of this project is to determine the seasonal effects and orchard factors that effect the fruit growth patterns and how these influence the permeability and storeability of Pink Lady apples. The problem of internal browning is likely to result from a combination of factors that in some seasons predisposes this variety to the disorder. To follow is some background to the hypothesis that this project is addressing. The hypothesis is that seasonal and orchard factors may influence the density or susceptibility of the fruit to the disorder in CA storage.

Pink Lady is a very dense apple that develops a greasy, waxy cuticle during ripening. The density of the fruit and the waxy cuticle developed during ripening and storage can limit the gas exchange of this variety. This means that gas diffusion through the flesh of the fruit can be limiting, resulting in the level of oxygen becoming too low or the level of CO_2 high, and this then damages the cortex of the fruit under certain CA storage conditions.

A summary of the factors that contribute to poor gas exchange includes;

- Temperature at fruit set influencing cell division and fruit density.
- Temperatures and crop load during cell expansion phase affect final fruit size.
- Greasiness of the skin relating to fruit maturity.

A combination of these factors may increase the risk of Pink Lady apples developing internal browning during CA storage.

It is possible that the internal browning disorder results from a reduced permeability of the fruit in some seasons. The permeability and density of the fruit is largely determined by climatic and orchard factors during the growing season.

For example, research has shown that temperatures during the first 1 – 4 weeks after fruit set (50 days after full bloom) influence both fruit size and fruit shape. The number of cells the fruitlet makes at this time is determined largely by seasonal temperatures. It is proposed that fruit with more cells are denser and so more prone to flesh browning during CA storage. Our project aims to determine what seasonal factors determine fruit density. With this information it may be possible to flag seasons where fruit are prone to this disorder and in those years growers can decide not to store susceptible fruit as long as in normal years.

The next important stage is when the cells expand. The peak growth rate is usually in early summer and at this time there is an intense flow of carbohydrate from mature leaves to into rapidly enlarging fruit. This means that other factors also influence final fruit size, such as crop load and shading, which determine how much carbohydrate goes to the leaves or the fruit. There is some evidence that apples with larger cells (eg, fruit trees thinned to a high leaf to fruit ratio) are more prone to this disorder. They also prone to nutrient deficiencies and this could be another factor that could be involved in the disorder.

Our project hypothesis is that seasonal factors predispose fruit to the disorder and that the disorder is the result of either too higher CO_2 level or too lower O_2 level in the cortex of the fruit during storage. This means that the CA atmosphere may also influence the development of the disorder.

A literature search turned up a paper written in 1967 which showed the flesh browning symptoms of Delicious apples stored in CA atmospheres with different combinations of oxygen and carbon dioxide (Photo 1). The results show that high carbon dioxide seems to induce flesh browning symptoms similar to that seem for Pink Lady apples.

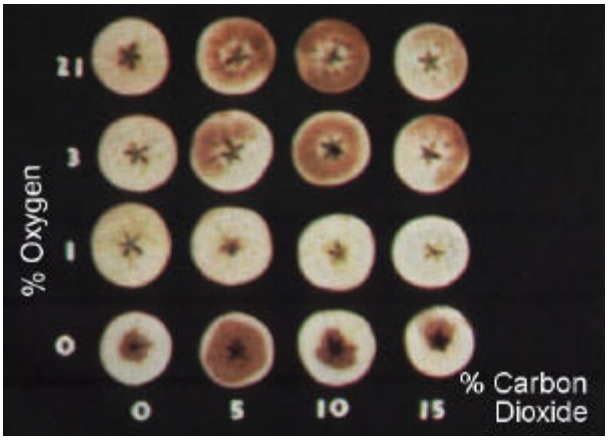

Photo 1. Symptoms of flesh browning in Delicious apples after 6 months storage at 0^oC and 7 days at 20^oC (Anderson, 1967).

In the 2002 season Sydney Postharvest Laboratory did some very preliminary research to determine if Pink Lady apples were sensitive to high CO_2 or low O_2. The results from these preliminary CA storage experiments

provide some insights into the possible causes of flesh browning in Pink Lady apples. The following series of photos is a summary of the results from our preliminary trials.

Photo 2. Symptoms of fruit stored in 20% CO_2 plus air at 20°C for 6 weeks.

Photo 3. Symptoms of fruit stored in 20% CO_2 plus air at 0°C for 6 weeks

Photo 4. Symptoms of fruit stored in 100% N_2 at 20°C for 6 weeks.

Photo 5. Symptoms of fruit stored in air at 0°C for 6 weeks

These photographs illustrate the following points -

- High CO_2 at 20°C causes browning but as spots rather than the commercially seen band of browning.
- High CO_2 at 0°C causes severe browning more similar to commercial symptoms.
- "Commercial" symptoms of flesh browning can be induced by promoting anaerobic respiration as a result of limited O_2. The internally produced CO_2 could be the cause of flesh browning.
- Induction of symptoms is relatively slow about 6 weeks at 20°C and so this is not a very rapid diagnostic test for susceptible fruit.

These results seem to indicate that Pink Lady apples are sensitive to CO_2 during storage. Although occurrence of the disorder is not simply the result of CO_2 in storage, this is probably just one factor in the equation.

Following on from these preliminary results Sydney Postharvest Laboratory in collaboration with Food Science Australia will try and address the following areas for the Flesh Browning of Pink Lady Apples Project (Horticulture Australia Project AP02009) in the 2003 season -

- Preliminary results suggest that the disorder may be a function of limited oxygen and or high CO_2 in storage.

- Permeation of oxygen may be related to fruit density which is related to growing conditions.
- Aim to store fruit in a matrix of atmospheres containing different 0_2 and CO_2 mixtures in an effort to induce flesh browning symptoms.
- Aim to correlate fruit density with the rate of induction of symptoms.
- Will carry out a mineral analysis to determine if B or Ca also play a role in inducing this disorder.

Reference:

Anderson, R.E. (1967) Experimental storage of eastern-grown 'Delicious' apples in various controlled atmospheres. Proc. Amer. Soc. Hort. Sci 91: 810 – 820.

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** Dr Jenny Jobling is Research Manager at Sydney Laboratory and is also the Project Leader of the HAL project AP02009 that is looking at understanding the flesh browning disorder of Pink Lady apples. This project began in July 2002 and run until 2004.*