Association Pink Lady® Europe	Ctifl	*TECHNICAL ANIMATIION* 15/07/2004
		Minutes of the international working party on Pink Lady® Internal Browning June 6th 2004, Verona (Italy)
		Drawn up by Vincent Mathieu-Hurtiger, Reviewed by Jenny Jobling, Marie Eve Biargues and Lise Pichon

Participants:

The working party:

- Jenny Jobling, project leader (Sydney Post Harvest Laboratory, Australia)
- David Tanner (Food Science Australia, Sydney, Australia)
- Stuart Tustin (Crop Physiology, Hort Research, Hawkes Bay, New Zealand)
- Gordon Brown (Scientific Horticulture, Tasmania, Australia)
- Beth Mitcham (University of California, Davis, California, USA)
- Ian Wilkinson (NRE Victoria, Australia)
- Angelo Zanella (Research Centre for Agriculture and Forestry Laimburg, South Tirol, Italy)
- Oswald Rossi (Research Centre for Agriculture and Forestry Laimburg, South Tirol, Italy)
- Lisa Schimanski (Scientific Horticulture, Tasmania, Australia)

Other participants:

- Lise Pichon (Association Pink Lady® Europe, France)
- Vincent Mathieu-Hurtiger (Ctifl, France)
- Marie-Eve Biargues (CEFEL, France)
- Lisa Cavicchi (Cisa (Centro Interprovinciale Sperimentazione Agroambientale) Mario Neri, Bologna, Italy)
- Dr Testoni (IVTPA, Milan, Italy)
- Horst Berger (University of Chile, Chile)

By way of introduction, Lise Pichon reminded the meeting that control over Internal Browning (IB) is a major issue for the development of the variety. Given that, in the years to come, increasing production will require that the sales campaign be extended, it will be necessary to understand the storage characteristics of Pink Lady®/Cripps' Pink cov. apples better in order to store them for longer periods.

Summary of the work of each of the participants

Jenny Jobbling :

There are three types of IB: diffuse, radial and brown-cavity type (CO_2 toxic type). The type of IB in question must be properly specified in each study.

A significant proportion of CO_2 seems to be one of the causes of IB, and especially the proportion of internal CO_2. Experiments show that adding wax, which brings about an increase in the proportion of internal CO_2 (3.1% as against 1.9%) and inhibits the proportion of ethylene, leads to IB. The wax treatment was used as an experimental tool to induce the symptoms as waxing prior to storage is not a commercial treatment. IB increases if the proportion of CO_2 in the atmosphere is significant (1% as against 0.03%). The effect of a high CO_2 content varies in inverse proportion to the level of oxygen (2%). The influence of ethylene is, in contrast, less clear.

Fruits picked when riper have more IB. After 9 months of storage, late picking in tandem with storage in CA gave the highest IB rates.
It is thought that the problem might be related to fruit density. Fruit with a lower density would appear to suffer less. The district (region) effect would also seem to play a part, in relation with the climate. Fruit from hot regions, which are not as dense, are thought to have more space between their cells for CO_2 to circulate. Denser fruit, which do not let CO_2 escape easily, might have higher proportions and so be more damaged. 2003 results are not, however, as clear.
The year has a significant effect (little IB in 2003, perhaps related to the climate?), as does crop load, but not nutrition (for the moment). In addition, the percentage of fruit suffering from IB does not seem to increase with storage time.

David Tanner:
Aweta acoustic sensor was used to determine which fruit suffered from IB (non-destructive method).
The aim of other work was to study the correlations between climatic factors and the occurrence of IB.
Risk modelling using monitoring of the temperature in the fields indicates that a low temperature in spring might increase the risk, since, in theory, a cooler temperature during the growth period should give denser fruit.
In addition, a low day-night temperature range before picking is thought to slow down the development of colouring. The fruit would be picked later and therefore at a more mature stage of development: they would therefore be more sensitive to IB.
By monitoring temperature at these two critical periods it might be possible to establish risk-prevention models.

Stuart Tustin:
A good correlation between the cortical density of the fruit and the amount of air inside it has been found, but not between the density of the fruit and this same quantity of air.
One of the difficulties in these experiments is to define the period at which these measurements must be made, since the fruit evolves differently depending on the seasonal climate.

Gordon Brown:
IB might be correlated with many factors which have been tested: root stock, root diseases, stage of ripeness, colouration methods. They have deduced the following points from this:
- fruit ripeness is an essential factor: an increase in IB was observed with late picking. Fruit must therefore be picked at the optimum stage of ripeness.
- Methods of improving fruit colouration have an impact on IB: cincturing trees in order to increase colour is not to be recommended, reflective fabrics being a preferable method.

The year also has a great impact: there was a lot of IB in 2000 and 2002 (between 40 and 50%); not much in 1999, 2001 in 2003 (between 0 and 15%).

Beth Mitcham:
There was little IB in 2003 as compared with 2002.
CO_2 seems to be one of the factors involved in IB especially for the brown-cavity type.
There was no problem when storing fruit with 20.8% of O_2 and 1% of CO_2, but this fruit appeared to have greater browning as the concentration of CO2 increased and the level of oxygen decreasedNutrition of the tree was analysed, but no clear link between nutrition and IB was established.
The problem does not seem to get worse after two months of storage.
DPA is said to reduce IB, whereas 1-MCP has no impact. However, the impact of DPA needs to be viewed with caution because in Tasmania they use it to but they do have IB. This perhaps has an effect only on the radial type IB, which is more prevalent in California? Tasmania have the diffuse type of browning.

Ian Wilkinson:

Three types of IB exist: senescence browning (diffuse), radial browning and one resembling CO_2 damage (brown-cavity).
1-MCP has no particular effect upon IB. Although overall incidence of browning in this trial was low.
A clear orchard effect was brought to light, some having up to 60% of IB while others had nothing wrong: this could be related to a district effect.
A significant variation is to be observed depending on the years: 2001 and 2003 were problem-free years unlike 2002 (Impact of nutrition? The crop load? Alternating orchards?).
In 2003, it tests on the incidence of CA and progressive cooling were performed but the low proportion of IB did not allow the effect of the treatment to be observed.

Angelo Zanella:

Very little IB was observed for the 2003-2004 season as compared with previous seasons. Some of the reasons might be: the pressure put on growers to respect the window of opportunity of the harvest and to respect the recommended fertilisation, the climate? Certain sites, moreover, have never contracted the problem (district and/ orchard effect).
The problem seems to increase after five months of storage..
It is more significant on late harvests (final picks).
For storage conditions, IB is greater with CO_2 contents higher than those of O_2 (4% for 1.8%). For O_2 contents greater than those of CO_2, the best results were obtained with the lowest O_2 contents (1.8%-1.3% better than 3.5%-1%). ULO (Ultra Low Oxygen) seems to increase the problem (1%-1%).
Gradually decreasing temperature and putting into delayed CA (one week at 5°, one week at 4° and one week at 2.5- 3°, then put into CA) gives good results in reducing the occurrence of the diffuse symptoms of IB.

Vincent Mathieu-Hurtiger:

A late harvest increases the risks of IB, especially so when associated with a low tree load. A similar result was found in New Zealand.
The orchard effect is undeniable, young orchards appearing to be more sensitive, but tree age is not the sole factor involved.
CA storage, even if this causes problems with sensitivity to CO_2, is essential in order to maintain fruit quality.
Temperature has an impact, since the problem is more acute at 0°C than at 4°C. But at 4°C, the fruit is of poor quality. Mid-range temperatures were tested in 2003, but no IB was noted.
For 1-MCP, tests performed in 2003 remained inconclusive.
IB increases after 7 days at ambient temperature.

Marie-Eve Biargue:

Late harvests increase the risks of IB (In 1999: 70% of IB with a late harvest as against 0% for an early harvest).
The problem increases after 7 days at ambient temperature.
Tests in 1999 and 2002 brought to light between 0 and 5% of IB at D1 and between 45-50% at D1+7 days.
Old orchards appear to be less sensitive than young ones.
1-MCP applied just after picking gave good results in 2002: less than 5% of IB as against 23% for the control.

Lisa Cavicchi:

She did not observe any IB in 2003, whatever the temperature, the atmosphere or the storage time.

Summary of presentations, recommendations and working strategy for the future

Three types of IB exist: type 1: diffuse (or senescent), type 2: radial and type 3:brown heart (or cavity or CO_2 toxic). According to the working party, the factors which could lead to these different types of IB appear to be:

- diffuse IB: a problem which appears to resemble senescence, which appears to be linked to an excessively ripe harvest, to a chilling injury in response to a rapid drop in temperature, to a "region" effect, an orchard effect and to the climate before the harvest (the impact of the temperature before the harvest).
- radial IB: a problem which is probably related to ripeness and to the CO_2 content during storage to the district (region), to the orchard, to the load on the trees, to the season (temperature influence) and fruit acclimatisation to cold before picking (fruit hardening?).
- brown heart IB: probably more related to sensitivity to CO_2 although other factors may perhaps be responsible. Not often seen commercially but can be induced with high CO_2 levels.

IB therefore seems to be triggered by a whole range of factors, with different parameters coming together to cause it. It is a complex mechanism. However, professionals need quick answers. The indications that can be a drawn from the work of the working party are:

- late harvests are more likely to develop IB. This is even more true with low crop loads on young orchards and if colouring is delayed.
- The climate affects the structure of the fruit, acting on its density.
- There seems to be a strong year effect, years with IB alternating with years without. The causes of this are not yet identified.
- The district (region) effect and the orchard effect seem to be significant.
- Cooling by stages (step wise cooling) reduces the level of IB as the fruit appears to be sensitive to cold.
- Pink Lady®/Cripps' Pink cov. apples are sensitive to high CO_2 content which seems to be intensified with a low O_2 content.
- Treatment with 1-MCP and DPA, is inconclusive as contradictory results have been obtained.

<u>Their recommendations for the profession</u> are therefore as follows:

- Growers must pick when optimal ripeness has been reached, according to the starch content and not to the colour in order to have fruit with a reasonable storage potential. Certain techniques to improve colouring may be used (reflective tarpaulins in particular). Storage duration must then be adapted to the potential risks.

(In Australia, distributors have lowered their requirements with respect to colour in keeping with the results of this research project)

- For storage in CA, the level of CO_2 must be less than 1% and the level of O_2 not too low (no ULO).
- In Italy, conservation in CA (with 1.8% O_2 and <1.3% CO_2) with gradual lowering of temperature (4°C during filling then 2 weeks at 3°C and the rest at 2.5°C, finally introducing the CA) and a storage temperature of 2.5°C have given results which reduce IB.

For the coming years, **<u>the working strategy</u>** chosen by the research group is as follows:

- Gain understanding of the relationship between "green life" (period before the climacteric rise) and the starch index.
- Develop a better test to assess ripeness of Pink Lady®/Cripps' Pink cov..
- Study the correlations between the structure of the fruit, the climatic models and the incidence of different districts (region) and develop predicted models to assess the risk of IB occurrence.
- Repeat the load tests in orchards, in Australia.
- Determine the optimum storage conditions for long term CA.

In the shorter term, to improve co-ordination within the group:

- Reach agreement on an IB severity index so that everyone can work on a common basis.
- Reach agreement on how to take photographs (how to cut, take a photo quickly) so that these are successful (no “parasite” oxidation).
- Make sure researchers record the type of symptoms they see in their trials
- Make sure researchers report what starch pattern index they use for assessing maturity at harvest