# RESEARCH AND COMMERCIAL EXPERIENCE WITH SMARTFRESH™ IN SOUTH AFRICA

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## *Introduction*

SmartFresh™ is an exciting new breakthrough in the post harvest storage of fresh fruit and vegetables. American scientists at North Carolina State University invented 1-methylcyclopropene (1-MCP), an antagonist ethylene inhibitor in horticultural products. The technology, now known as SmartFresh™, has been acquired and developed for use on fresh fruit and vegetables by AgroFresh Inc, a Rohm and Haas Company. Due to its ethylene blocking effect, SmartFresh™ has incredible potential to maintain the quality of fresh produce during cold storage and shelf life.

SmartFresh™ has been approved for use on apples and other crops in U.S.A., Chile, Argentina, Mexico, New Zealand and most recently South Africa and the United Kingdom.

For the past three years Capespan Technology Development (CTD) has been conducting research on SmartFresh™ for AgroFresh (Inc) on South African fruit. Consistent with findings of overseas researchers, it has been established that SmartFresh™ treatment on apples enables maintenance of flesh firmness, skin colour and malic acid levels, and when applied under the recommended guidelines, complete superficial scald control. Other benefits from the use of SmartFresh™ include extended shelf life and a reduction in greasiness.

During the 2003 season, CTD developed a service system for AgroFresh (Inc) which included the following tasks for each treated room:

1. Checking the gas-tight integrity of the room if required (if not a certified CA room)
2. Removal of a fruit sample for a complete maturity analysis
3. Removal of a fruit sample of untreated control fruit
4. Application and activation of SmartFresh™ generators
5. Removal of a sample of fruit treated with SmartFresh™
6. Placing of an untreated sample back in the room should the room be placed under controlled atmosphere (CA)
7. Measurement of internal ethylene levels seven days after treatment to determine efficacy of treatment
8. Feedback and advise on efficacy of treatment to AgroFresh (Inc) and Pack house if required
9. Examination of regular atmosphere (RA) holdback samples after 4 months storage at -0.5 °C (full maturity and internal ethylene determination)
10. Examination of CA holdback samples 4 weeks after CA rooms are opened.

From an extensive database of over 100 treatment rooms, the effect of commercially applied SmartFresh™ on fruit maturity at treatment, storage duration, RA vs. CA storage, and different apple cultivars, was determined.

***Benefits of Commercially applied SmartFresh™***

SmartFresh™ was applied across a range of apple cultivars with the following split: Granny Smith 34%, Golden Delicious 35%, Royal Gala 17%, Reds 8% and Pink Lady® brand 7%. Fifty percent of all Granny Smith rooms treated with SmartFresh™, 80% of Golden Delicious and Royal Gala rooms and 90% of Pink Lady® brand and Reds were maintained under CA. Monitoring of the internal ethylene status of treated fruit seven days after treatment provided a quick indication of treatment efficacy. Ethylene levels in treated fruit were usually an order of magnitude lower than in untreated fruit and were rarely above 5ppm.

The results of samples treated with SmartFresh™ and stored under RA conditions for 4 months can be seen in Table 1. These values represent means across all rooms regardless of treatment efficacy and so is an accurate representation of commercial SmartFresh™ application. In most cases, flesh firmness was improved by at least 1 kg. Exceptions to this were when treated fruit were of an advanced maturity leading to a reduction in treatment efficacy. For most cultivars tested, SmartFresh™ held back yellowing of fruit. Superficial scald was completely controlled when SmartFresh™ was applied according to the treatment guidelines. The two rooms where slight superficial scald was noted could be explained by the presence of fruit outside of the seven-day treatment protocol. These fruit were producing high levels of ethylene that negated the efficacy of SmartFresh™. SmartFresh™ slightly increased levels of bitter pit in Granny Smith and Golden Delicious apples, but reduced the incidence of the disorder in Royal Gala and Red Delicious apples. Eliminating bitter pit at source reduces the risk of export rejections at the overseas distribution hubs.

Fruit treated with SmartFresh™ and maintained under CA were stored until the commercial rooms where opened. SmartFresh™ treated fruit stored under RA were of a higher quality compared to untreated RA control fruit, with lower levels of superficial scald and higher flesh firmnesses (Table 2). There was very little difference between SmartFresh™ RA fruit and untreated fruit stored under CA conditions. Storing SmartFresh™ treated fruit under CA however, resulted in further benefits to fruit quality, in that skin colour change was held back and flesh firmness maintained more effectively. In the CA sample sub set of apples, no fruit treated with SmartFresh™ exhibited superficial scald when stored under either RA or CA conditions. It must be noted that CA designated fruit is sourced from optimum harvests where fruit has the greatest storage potential.

Fuji and Sundowner were tested for the first time during the 2003 season (Table 1). The Fuji apples had a starch breakdown of 70% indicating fruit of an advanced maturity. SmartFresh™ treatment resulted in an increase in the incidence of lenticel spot from 12.9% to 23.7%. Like bitter pit, early expression of this disorder allows elimination prior to packing, which reduces the likelihood of substandard quality fruit arriving at overseas destinations. Sundowner, was also treated at an advanced maturity with a starch breakdown of 80%, but maintained a firmness improvement of 1.0kg after 4 months of RA storage.

It is important to apply SmartFresh™ within seven days of harvest to fruit of the correct maturity. When Golden Delicious apples were treated after three months of CA storage, the benefits of SmartFresh™ were markedly reduced. Flesh firmness was only improved by 0.3kg, and 20% of the fruit developed superficial scald. Internal ethylene levels between treated and untreated fruit were very similar indicating that SmartFresh™ was no longer effectively blocking the ethylene receptors. At the time of treatment no starch was present in the fruit. Similarly, when Pink Lady® brand apples were treated with SmartFresh™ after four weeks of RA storage, the benefits usually associated with SmartFresh™ treatment were marginal, with low levels of superficial scald developing. Loss of treatment efficacy may also occur if a treatment room contains more than one cultivar of fruit, especially if one of the cultivars were picked more than 7 days prior to treatment.

***Prediction of treatment efficacy***

Using the data base, maturity parameters at treatment were compared with quality responses after storage. From this data, it was immediately evident that the most important factors effecting SmartFresh™ efficacy were starch levels, followed by flesh firmness. When fruit were treated with less than 40% starch break down, flesh firmness improvement at the end of cold storage was invariably greater than 1.0kg. It was also evident that SmartFresh™ was no longer effective above a certain level of starch break down in the fruit. This varied for cultivars but was normally between 50 and 65%. An exception to this was Pink Lady® brand apples, where firmness differences above 1kg were noted in fruit with 90 to 100% starch break down.

This data was also analyzed statistically in a forward stepwise regression procedure, where the significant level for the inclusion of an independent variable was 5% and for that variable to stay in the model 10%. The coefficient of determination was calculated as $R^2$ and the contribution of each variable in the model as partial $R^2$'s. A simple example of this model is given below for a predicted firmness improvement in treated Royal Gala apples. The selected independent variables were the starch level at treatment, and the internal ethylene value of both the untreated and treated fruit. The sum of the partial $R^2$'s was 0.7068 which represented a prediction certainty of approximately 71%. The actual values were taken from a random Royal Gala room where the starch break down ($Starch_{Breakdown}$) at treatment was 32.5% and the internal ethylene levels for untreated ($Eth_{Cont}$) and treated ($Eth_{SF}$) fruit after 7 days were 123 ppm and 1.3 ppm, respectively:

$$\text{Predicted Firmness Improvement} = Starch_{Breakdown}(-0.015) - Eth_{Cont}(0.002) - Eth_{SF}(0.001) + 2.068$$
$$= 32.5(-0.015) - 123(0.002) - 1.3(0.001) + 2.068$$
$$= 1.4 \text{ kg}$$

In this example the actual firmness difference was 1.6 kg. The accuracy of the model depends on the number of data points. At this point in time, the model has some errors, due to small sample size and variability within harvest maturity and fruit quality. As new data is collected during the next few seasons and added to the database, the accuracy of the model will improve.

***Conclusion***

Positive feedback from pack houses, different exporters and supermarkets confirm the results that were found in the hold back samples. Rooms that didn't respond as favorably as hoped to SmartFresh™ treatment could be explained by the level of starch break down in the fruit which

was often an indication of fruit outside of the treatment protocol, or post optimum fruit harvested at an advanced maturity. These results emphasize the importance of treating high quality fruit. Treatment rooms can only contain more than one cultivar if both cultivars are within the seven day treatment protocol and of similar maturity. An important aspect with the use of SmartFresh™ is to treat fruit at the correct harvest maturity and at the correct dosage rate. Capespan Technology Development is currently screening all major apple, pear and plum cultivars to determine optimum picking maturities, storage parameters and duration of storage to obtain the best benefit from SmartFresh™.

**Table 1.** Summary of quality differences between SmartFresh™ treated fruit and untreated fruit after four months storage in regular atmosphere at –0.5 °C and seven days at 15 °C. Values represent means across all room treatments for each cultivar.

| Cultivar | Flesh Firmness (kg) | | Skin Colour[1] | | Bitter Pit (%)[3] | | Superficial Scald (%)[4] | |
|---|---|---|---|---|---|---|---|---|
| | Control | SF | Control | SF | Control | SF | Control | SF |
| Granny Smith | 5.8 | 6.8 | 1.9 | 1.9 | 0.0 | 0.2 | 35.8 | 3.8 |
| Golden Delicious | 4.9 | 5.7 | 4.5 | 4.3 | 0.1 | 0.5 | 10.1 | 0.03 |
| Royal Gala | 5.7 | 6.4 | 4.4 | 4.3 | 1.6 | 0.5 | 0.0 | 0.0 |
| Pink Lady® brand | 6.3 | 6 | 3.9 | 3.7 | 0.0 | 0.0 | 2.9 | 0.5 |
| Red Delicious | 5.6 | 7.2 | – | – | 2.7 | 0.5 | 8.1 | 2.1 |
| Fuji [2] | 6.4 | 6.7 | 3.2 | 3.2 | 12.9 | 23.7 | 0.0 | 0.0 |
| Sundowner | 5.7 | 6.7 | 3.2 | 3.3 | 0.0 | 0.0 | 0.0 | 00 |

[1] Skin colour, where 0.5 = green and 5 = yellow on the Hortec® colour chart for green apples
[2] Fuji and Sundowner results represent only one treatment sample
[3] In the case of Fuji, the disorder noted was lenticel spot
[4] These values represent averages of all scalded fruit. When SmartFresh™ was correctly applied, complete superficial scald control was obtained.

**Table 2**. Summary of quality differences between SmartFresh™ treated fruit and untreated fruit stored under CA conditions until opening of rooms and then 4 weeks under RA at –0.5 °C and seven days at 15 °C. Values represent means across all room treatments for each cultivar.

| Cultivar | Flesh Firmness (kg) | | | | Skin Colour[1] | | | | Superficial Scald (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RA | | CA | | RA | | CA | | RA | | CA | |
| | Control | SF | Control | SF | Control | SF | Control | SF | Control | SF | Control | SF |
| Granny Smith | 6.1 | 6.6 | 6.5 | 6.9 | 1.9 | 1.7 | 1.8 | 1.6 | 39 | 0.0 | 15 | 0.0 |
| Golden Delicious | 4.8 | 5.7 | 5.8 | 6.2 | 4.0 | 3.8 | 3.7 | 3.6 | 28 | 0.0 | 0.1 | 0.0 |
| Royal Gala | 5.2 | 6.1 | 6.1 | 6.4 | 4.4 | 4.4 | 4.3 | 4.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Pink Lady® brand | 5.7 | 6.9 | 6.7 | 7.4 | 3.8 | 3.7 | 3.6 | 3.5 | 1.3 | 0.0 | 0.0 | 0.0 |

[1] Skin colour, where 0.5 = green and 5 = yellow on the Hortec® colour chart for green apples