EFFICACY OF SMARTFRESH^{SM} APPLICATIONS TO PALLETISED CARTONS OF APPLES

IAN CROUCH, HELEEN BERGMAN & HANDRE VILJOEN

ExperiCo (Fruit Technology Solutions), P O Box 4022, Idas Valley, Stellenbosch, 7609, South Africa

Research financed by Fruitgro^{Science} on behalf of the South African Apple and Pear Producers Association

The commercial application of SmartFresh^{SM} to apples has increased significantly over the last five years and is now a recognised technology in the South African deciduous fruit industry and worldwide. While the cost of treating fruit in bins is comparable to controlled atmosphere storage and some advanced MAP technologies, ways in which to become more cost effective in the use of SmartFresh^{SM} are always under the spotlight. The question has frequently been asked whether or not SmartFresh^{SM} can be applied to packed apples for two main reasons, first, to lower application cost of treating fruit not destined for export, and second, to facilitate treatment in the transit chain. On occasion, where packed fruit require extended storage, a second re-treatment may be required and fruit in this instance may be in packed palletised cartons.

This communication provides an update on research conducted by **ExperiCo**, on behalf of the South African Apple and Pear Producers Association (SAAPPA), to determine how different bag types affect SmartFresh^{SM} penetration into cartons, and to investigate the effectiveness of SmartFresh^{SM} penetration within a pallet of fruit. Granny Smith and Golden Delicious apples were used during the trial, and superficial scald development was used as an accurate indicator of SmartFresh^{SM} efficacy. It is important to note that results from this laboratory research should be followed by semi-commercial trialling across all packaging variations, prior to any industry recommendations and acceptance.

Penetration of SmartFresh^{SM} through unpalletised cartons with different bag types

It has been reported that the active molecule of SmartFresh^{SM} (1-MCP) is able to diffuse through bags up to a thickness of 60 µm. The initial aim of this trial was to determine the ability of exogenously applied SmartFresh^{SM} to penetrate a range of securely closed outer bags of different thicknesses, without compromising fruit quality or moisture loss. An unbagged control was used to determine optimum SmartFresh^{SM} efficacy. For each bag type tested, fruit were: (i) not treated with SmartFresh^{SM} (control), (ii) treated with SmartFresh^{SM} and then stored in the bag, or (iii) packed in the bags and then treated with SmartFresh^{SM}. Treatments included the standard industry 37.5 µm apple and pear bag, either without, or with perforations (Beurre Hardy bag), and a thinner 20 µm non-

perforated grape bag. Bags were securely closed with a cable-tie. SmartFresh[SM] application resulted in firmer fruit with no superficial scald development, compared to untreated fruit after 8 weeks cold storage, regardless of whether a bag was present (Table 1). SmartFresh[SM] efficacy was not compromised by bag thickness or whether perforations were present or not. Fruit internal ethylene readings confirmed these results, indicating complete ethylene inhibition, regardless of bag presence.

Table 1: Effect of bag type and time of SmartFresh[SM] application to unpalletised cartons on the quality of Granny Smith apples stored for 8 weeks at –0.5°C followed by a shelf life period of 7 days at 20°C

Bag Type	Time of SmartFresh[SM] application	Flesh firmness (kg)	Superficial Scald (%)	Internal ethylene (ppm)
No bag	No SmartFresh[SM]	6.7	84.8	84.0
	Before packing	7.3	0.0	0.0
Standard 37.5 µm (Non-perforated)	No SmartFresh[SM]	7.0	22.8	11.0
	Before packing	7.9	0.0	0.0
	After packing	7.2	0.0	0.0
Standard 37.5 µm (Perforated)	No SmartFresh[SM]	6.6	93.2	11.0
	Before packing	6.9	0.0	0.0
	After packing	7.3	0.0	0.0
Grape 20 µm LD (Non-perforated)	No SmartFresh[SM]	6.6	97.0	8.9
	Before packing	7.1	0.0	0.0
	After packing	7.2	0.0	0.0

Penetration of SmartFresh[SM] through a pallet

The initial part of this study indicated that SmartFresh[SM] has the ability to penetrate outer bags up to a thickness of 37.5 µm with no adverse effect on flesh firmness retention or superficial scald control. The second part of the study examined whether SmartFresh[SM] efficacy was compromised when applied to fruit packed and palletised for export. Initially Golden Delicious apples were packed in standard 37.5 µm bags, in 500 mm x 333 mm (M18T / MK IV) or 400 mm x 300 mm (M12T / MK VI) footprint telescopic cartons and subjected to passive application of SmartFresh[SM]. Bags were folded closed according to industry standard practice. Later, Granny Smith apples were packed in thinner 20 µm grape bags in 600 mm x 400 mm footprint (A/B/C12D / MK IX) display cartons and subjected to SmartFresh[SM] application under forced-air cooling (FAC) conditions. The findings of significance are summarised as follows.

In 2006, the first year of trialling, palletising and treating packed MK IV and MK VI cartons of Golden Delicious apples resulted in compromised SmartFresh[SM] efficacy the fewer number of carton sides directly exposed to the treatment at the outside of the pallet stack (Figure 1). When two sides of the carton were exposed to SmartFresh[SM] application, quality results were similar to the unbagged SmartFresh[SM] control. Treating palletised fruit with SmartFresh[SM] reduced the efficacy of the product to control superficial scald, with up to 5.1% noted in palletised cartons subjected to SmartFresh[SM]

(results not shown). Fruit internal ethylene readings confirmed these results, indicating reduced ethylene inhibition the fewer the number of carton sides exposed to SmartFresh^{SM}. Ethylene levels of SmartFresh^{SM} treated fruit were still at least an order of magnitude lower than that of control fruit.

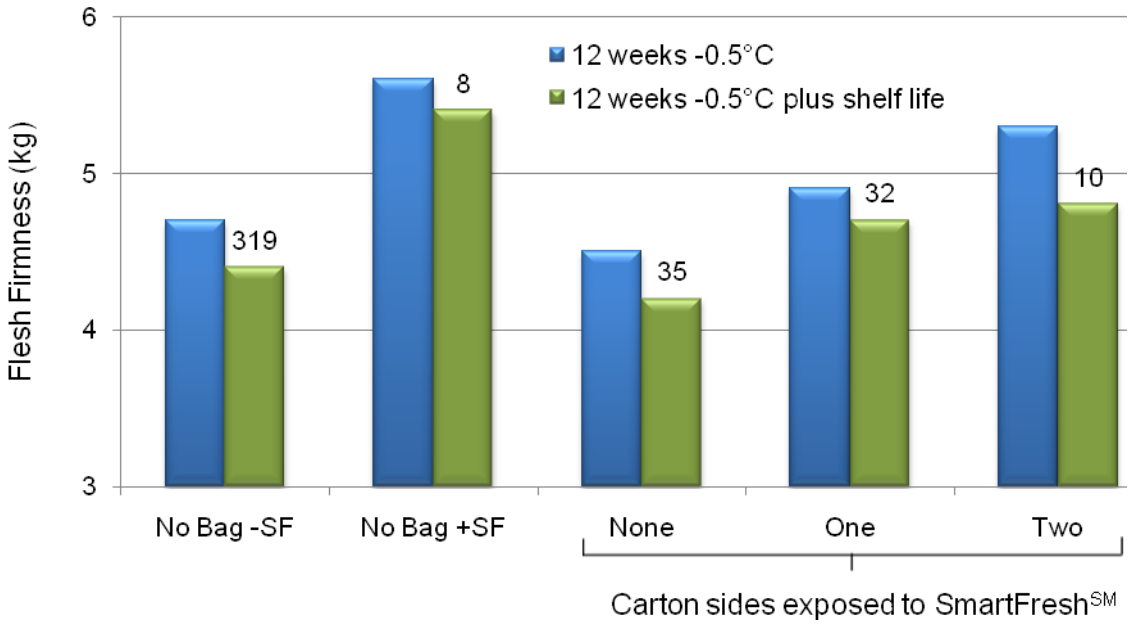

Figure 1: Flesh firmness of 2006 season Golden Delicious apples commercially packed into MK VI cartons, palletised and exposed to SmartFresh^{SM} (SF). Cartons divided into those with no sides, one side, or two sides exposed to the application. Fruit were stored at –0.5°C for 12 weeks followed by a shelf life period 7 days at 20°C. Numbers on green bars represent internal ethylene levels after shelf life.

In the 2007 season the efficacy of SmartFresh^{SM} to maintain fruit quality and control superficial scald on palletised optimum harvested Granny Smith apples was determined. SmartFresh^{SM}, applied to palletised MK VI cartons with or without 37.5 µm bags, resulted in improved flesh firmness (Figure 2) and skin colour (data not shown) compared to untreated fruit. However, while SmartFresh^{SM} application to palletised, bagged fruit drastically reduced scald relative to the control, it again failed to provide adequate control of superficial scald (± 10%) (Figure 3). Internal ethylene readings confirmed these results, indicating reduced ethylene inhibition in palletised, bagged SmartFresh^{SM} treatments.

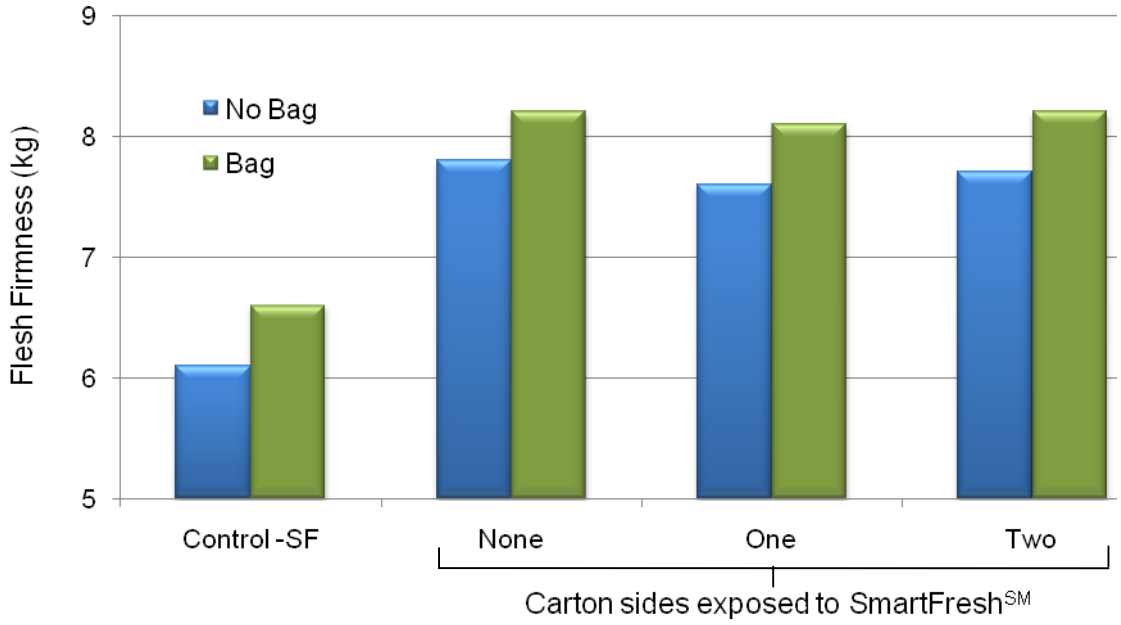

Figure 2: Flesh firmness of 2007 season Granny Smith apples packed into MK VI cartons, either without bags or with a bag palletised and exposed to SmartFresh℠ (SF). Fruit were stored for 24 weeks at –0.5°C followed by a shelf life period of 7 days at 20°C. Cartons were divided into those with no sides, one side, or two sides exposed to the application

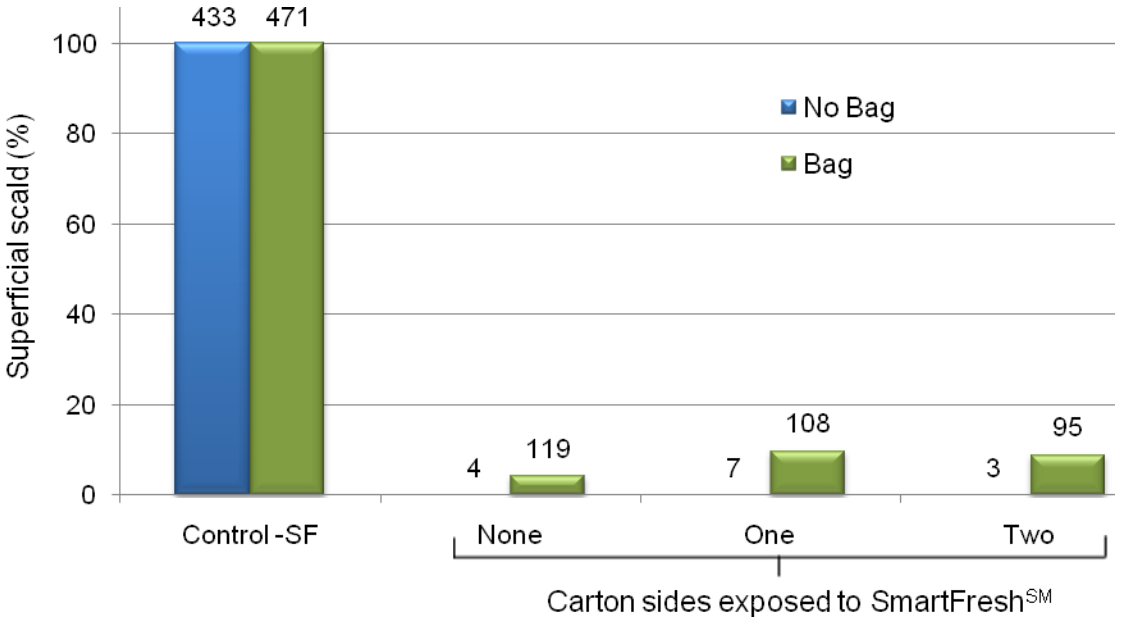

Figure 3: Superficial scald development of 2007 season Granny Smith apples packed into MK VI cartons, either without bags or with bags, palletised and exposed to SmartFresh℠ (SF). Fruit were stored for 24 weeks at –0.5°C followed by a shelf life period of 7 days at 20°C. Cartons were divided into those with no sides, one side, or two sides exposed to the application. Numbers on bars represent internal ethylene levels after shelf life

Since results indicated that unbagged, palletised fruit could be effectively treated with SmartFresh^{SM}, but that a 37.5 µm bag compromised scald control, a thinner bag was tested in 2008 in an attempt to improve SmartFresh^{SM} penetration through the pallet. Fruit were packed in 20 µm grape bags in MK VI cartons. Instead of passive cooling, the pallet was subjected to forced-air cooling (FAC) in an attempt to "pull" the SmartFresh^{SM} through the pallet. SmartFresh^{SM} maintained flesh firmness (Figure 4), but again palletisation of bagged cartons resulted in compromised superficial scald control with levels above 20% (Figure 5). No significant differences in other maturity parameters occurred regardless of the number of carton sides exposed to the SmartFresh^{SM} treatment (data not shown).

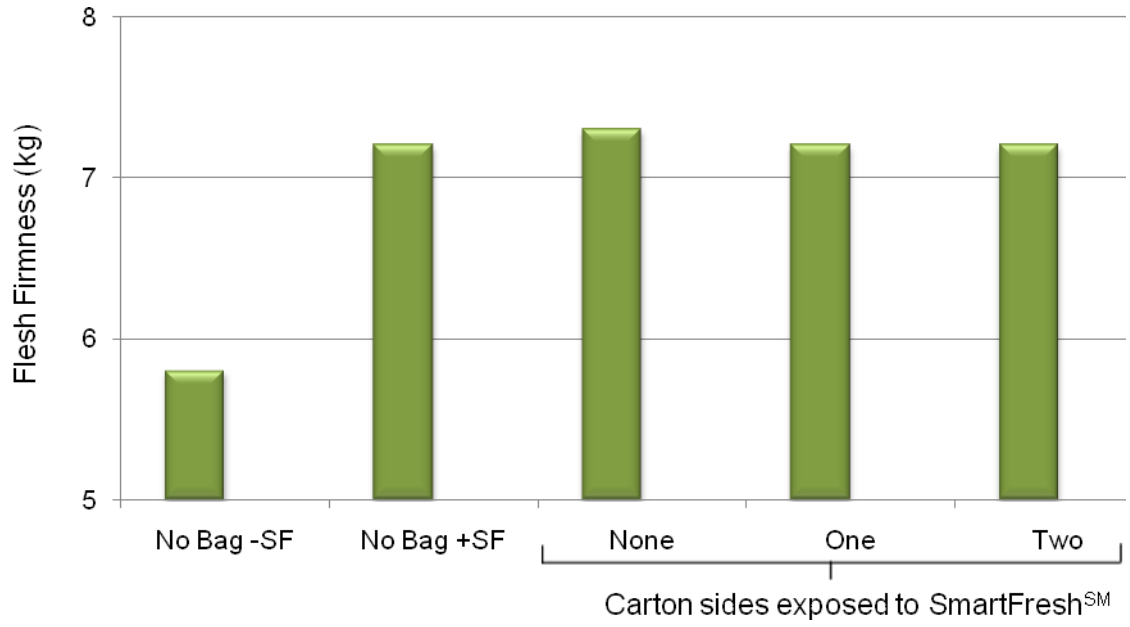

Figure 4: Flesh firmness of 2008 season Granny Smith apples packed into MK VI cartons, with 20 µm grape bags, palletised and exposed to SmartFresh^{SM} (SF). Fruit were stored for 20 weeks at –0.5°C followed by a shelf life period of 7 days at 20°C. Cartons were divided into those with no sides, one side, or two sides exposed to the application

In 2009, the final year of the study, MK IX display cartons were used, as opposed to telescopic cartons tested in previous years. These cartons always had at least one side exposed on the outside of the pallet unlike the MK VI cartons which had a central column of cartons with no sides exposed to the SmartFresh^{SM} application. Cartons were packed with 20 µm grape bags, palletised and subjected to SmartFresh^{SM} application during FAC. In this packing format, SmartFresh^{SM} efficacy was not compromised. Both flesh firmness (Figure 6) and superficial scald levels (Figure 7) were comparable between the SmartFresh^{SM} treatments irrespective of whether an outer bag was used or not, or how many sides of the carton were exposed. Relative to the non-SmartFresh^{SM} treated controls, all SmartFresh^{SM} treatments provided good maintenance of fruit quality.

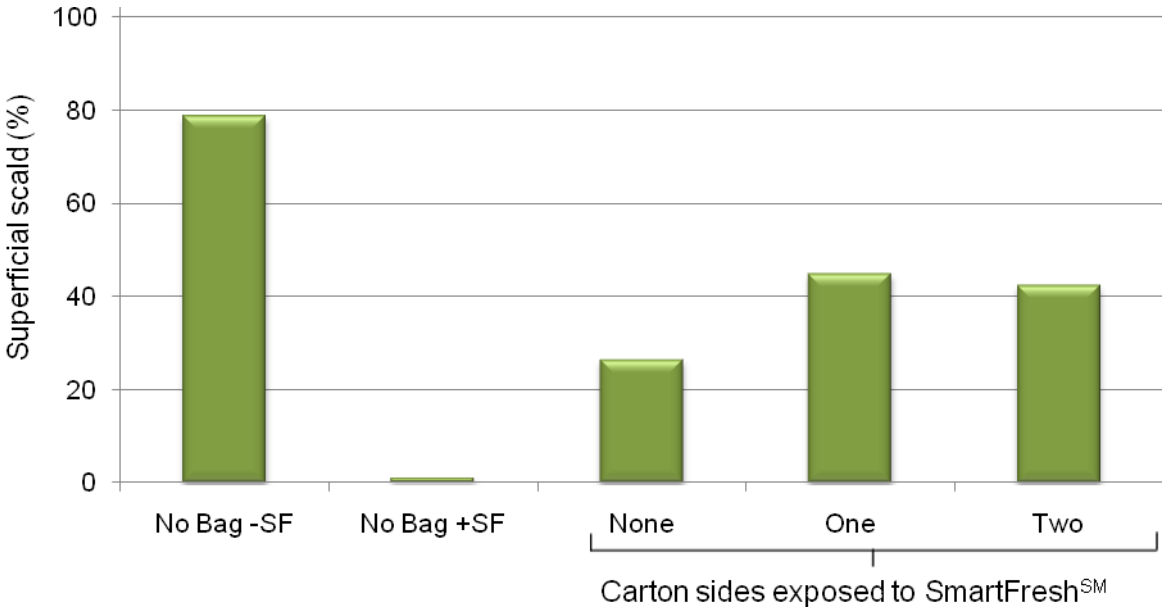

Figure 5: Superficial scald development of 2008 season Granny Smith apples packed into MK VI cartons, with 20 µm grape bags, palletised and exposed to SmartFresh℠ (SF). Fruit were stored for 20 weeks at –0.5°C followed by a shelf life period of 7 days at 20°C. Cartons were divided into those with no sides, one side, or two sides exposed to the application

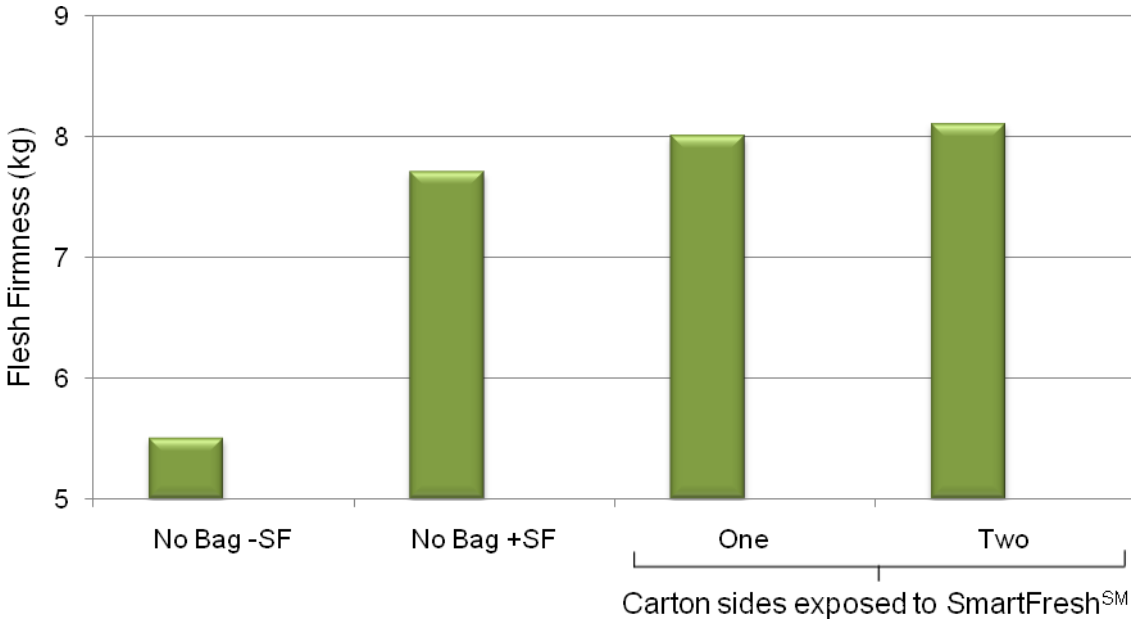

Figure 6: Flesh firmness of 2009 season Granny Smith apples packed into MK IX cartons, with 20 µm grape bags, palletised and exposed to SmartFresh℠ (SF). Fruit were stored for 20 weeks at -0.5°C followed by a shelf life period of 7 days at 20°C. Cartons were divided into those with one or two sides exposed to the application

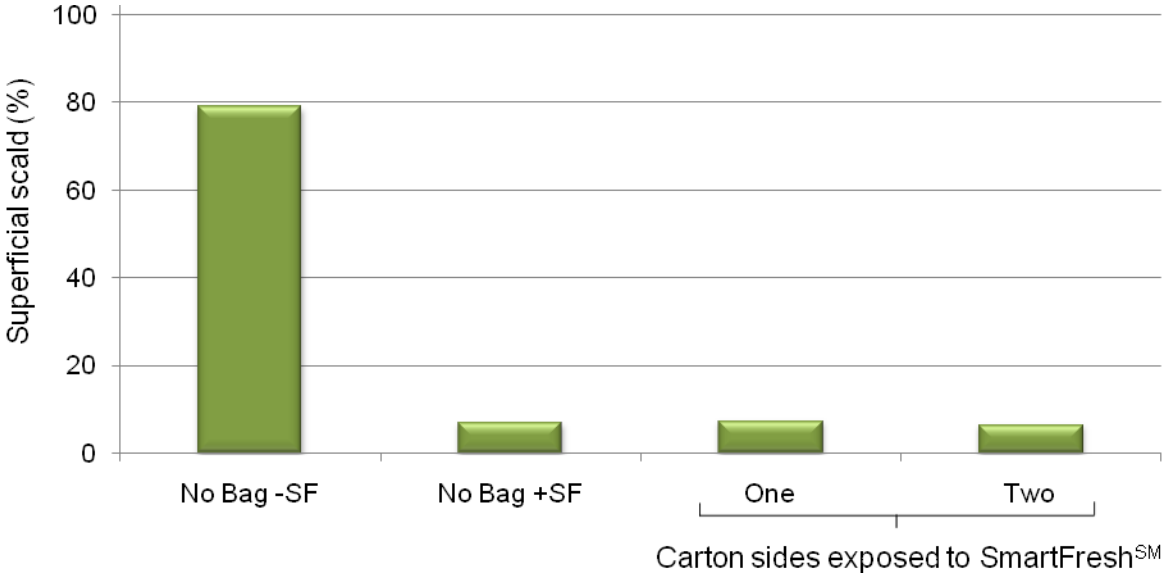

Figure 7: Superficial scald development of 2009 season Granny Smith apples packed into MK IX cartons, with 20 µm grape bags, palletised and exposed to SmartFresh℠ (SF). Fruit were stored for 20 weeks at –0.5°C followed by a shelf life period of 7 days at 20°C. Cartons were divided into those with no sides, one side, or two sides exposed to the application

Conclusion

While SmartFresh℠ has the ability to penetrate bags up to a thickness of 37.5 µm, the application of SmartFresh℠ to palletised telescopic cartons with 37.5 µm bags resulted in unacceptable levels of superficial scald. The use of thinner 20 µm bags did not solve this problem, unless used in a MK IX display carton with SmartFresh℠ applied under FAC. Therefore, cultivars not prone to shrivel, such as Granny Smith, could be packed in MK IV or MK VI telescopic cartons without a bag and effectively be treated with SmartFresh℠. However, the effect of packing fruit without bags on other quality parameters such as skin colour, greasiness and internal browning would need to be assessed. If retention of flesh firmness is the objective of an in-carton SmartFresh℠ treatment in MKIV and MKVI telescopic cartons, it would be important that scald potential apples have received a prior treatment of DPA, or a SmartFresh℠ application to binned fruit as per stipulated protocol. From a scientific point of view, an important finding of this study was the use of levels of superficial scald, in susceptible populations of Granny Smith, as a more sensitive SmartFresh℠ efficacy barometer than flesh firmness or any other maturity indexing parameter.

Currently, plums and pears are the most common fruit kinds treated with SmartFresh℠ in the palletised form. In the case of plums, palletised fruit are packed for export utilising a macro-perforated plastic wrapper to reduce moisture loss. This type of packaging has not been found to compromise SmartFresh℠ efficacy. Pears on the other hand may still be packed in telescopic or display cartons in standard 37.5 µm bags. This study suggests that unless the fruit are packed without bags, or in a

suitable carton format such as the MK IX display carton, and subjected to SmartFresh^{SM} application during FAC, efficacy may be compromised. SmartFresh^{SM} treatment in this packaging format in shipping containers should also be tested as the airflow dynamics are different to conventional FAC. This could result in an uneven treatment profile through the pallet which may result in varied ripening potential of fruit. The best SmartFresh^{SM} application method to ensure optimum efficacy is still to treat the fruit in bins as soon as possible after harvest.