

SEMI-COMMERCIAL EVALUATION OF SMARTFRESH™ WITH SOUTH AFRICAN EXPORT AVOCADOS IN STATIC CONTAINERS AT THE WESTFALIA PACKINGHOUSE DURING 2002.

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ABSTRACT:

During the 2000 and 2001 seasons, intensive laboratory testing was done with 1-methyl cyclopropene (1-MCP) an ethylene blocker on avocado fruit. All the major South African cultivars were tested and aspects such as storage potential, respiration rate and fruit quality upon ripening were covered. The results were extremely positive and the manufacturer (Rohm & Haas, USA) has subsequently registered the powder formulation of the product in South Africa at an application rate of 500 ppb and an exposure period of 12 hours. During 2002, a tablet formulation of 1-MCP, SmartFresh™ was tested under semi-commercial conditions on 'Fuerte' and 'Hass' at the Westfalia packhouse in Tzaneen. The product was applied in a static reefer container. SmartFresh™ was found to effectively inhibit the ripening process of 'Hass' and 'Fuerte' under the semi-commercial conditions described above. The inhibition of ripening was more intense in 'Fuerte' than in 'Hass'. Furthermore, the inhibition of ripening was more intense in the smaller count 18 fruit than in the bigger count 10-12 fruit. The increase in storage life was found to be comparable to that attained with control atmosphere storage (CA) when Smartfresh™ was applied at the optimum dosage.

The most appropriate packhouse based dosage regime for all sized fruit of both cultivars was found to be 300 ppb applied for 16 hours. The period may be prolonged to 36 hours if done in a refrigerated truck *en route* to the port of export and the treatment must preferably be started within 3 days after harvest.

INTRODUCTION:

In the past, the firmness of export avocados was maintained by reducing the storage temperature during transport. However, temperature control alone will not prevent ripening during a 28 day export period, especially during the late season. Since 1996, controlled atmosphere (CA) became available in South Africa as an additional tool to reduce ripening during storage. Due to the success of this method, virtually all avocado's are currently exported under CA. This method certainly improved the chances of landing a hard fruit in Europe and extended the harvesting window. Cold storage and CA both delay the ripening process by slowing down the metabolism of the fruit.

During the 2000-2001 seasons, the ARC-ITSC has been evaluating the effectiveness of SmartFresh™ a product containing an ethylene inhibitor, 1 - methyl cyclopropene (1-MCP), on avocados (Lemmer *et al.*, 2002). The trials were done in the laboratory using all the major export cultivars and covered aspects such as storage potential, respiration rate and fruit quality upon ripening.

The main conclusions drawn from the initial laboratory based trials were:

- SmartFresh™ slows down the ripening process of avocado under export simulation conditions.
- The ripening retarding effect is more intense on slow metabolizing CV's such as Ryan compared to CV's with a faster metabolism such as Hass

- SmartFresh™ can be applied over a wide range of concentrations and a dosage effect exists.
- SmartFresh™ can be applied at the temperature the fruit are to be exported at
- Storage potential of SmartFresh™ treated fruit is comparable to CA fruit.
- SmartFresh™ suppresses respiration rate to a greater extent than CA
- SmartFresh™ reduces greypulp under laboratory conditions
- The storage period is not to be over extended as this may increase the incidence of fungal pathology.

Due to the extremely positive results, the manufacturer (Rohm & Haas, USA) has registered the powder formulation of the product on avocados in South Africa at an application rate of 500 ppb and an exposure period of 12 hours.

During 2002, a tablet formulation, SmartFresh™ was tested under semi-commercial conditions on 'Fuerte' and 'Hass' at the Westfalia packhouse in Tzaneen. The product was applied under packhouse conditions in a static reefer container. The research aimed to determine suitable application periods and optimum dosage regimes for 'Fuerte' and 'Hass' avocado fruit.

MATERIAL AND METHODS:

Fruit:

In the case of 'Fuerte' count 18 (211-235g) and count 10 (366-450g) fruit were used. In the case of 'Hass' count 18 and count 12 (306-365g) fruit were used. Freshly harvested and packed export fruit were sampled for the trials.

Treatments:

Taking the previous results into consideration, it was decided to include two SmartFresh™ concentrations (300 ppb and 500 ppb) and to treat the fruit for 16 hours. On packhouse management request, a 8 hour regime was also included in one of the trials. In all cases, the SmartFresh™ treated fruit were compared with untreated control fruit from the same batch.

Smartfresh™ treated fruit were also compared with CA stored fruit ($\text{CO}_2 = 6\%$ and $\text{O}_2 = 4\%$). A flow-through CA system (consisting of a 100l drum connected to gas regulators and a CA control board) was installed in a Westfalia cold room for this purpose.

Treatment application and storage:

Two 58m³ reefer shipping containers were parked at Westfalia packhouse for the duration of the 2002 season. One container was air-tightened and used for treating the fruit while the second was used for cool storage.

A total number of 11 container loads were treated during the season. 'Fuerte' fruit were treated on 18 April, 25 April, 5 June, 23 July, 24 July, 31 July, 2 August and 'Hass' fruit were treated on 5 June, 23 July, 24 July, 2 August, 26 August, 27 August, 28 August, 29 August and 30 August. During the first two trials, export fruit samples (3 boxes per size) were placed in the center of 20 pallets. The rest of the pallets consisted of local market fruit. The aim of the experiment was to establish whether the 1-MCP gas diffused evenly through the container from the point of release at the door. After the application period of 16 hours, the doors and the vents were opened. The pallets were removed and 10 of the

pallets were replaced with pallets containing control untreated samples. The pallets were placed in the same order, from the condenser side towards the door of the container. The fruit were stored inside the container with the vents 15% open to simulate the export period to Europe. After a 28 days storage period at the SAAGA prescribed temperature regime, the fruit were ripened at 18°C and evaluated.

During the remaining 9 trials, the treatment container was filled with bulk bins containing local market fruit. Two sets of export fruit samples (three boxes of each count) were placed near the condenser and door, on top of the bulk bins. After treatment, the sample fruit were removed from the pallets and stored in the second empty container.

Evaluation criteria:

Individual fruit were comprehensively evaluated as they ripened. This was done by the application of moderate finger pressure to the fruit on a daily basis. Densimeter readings were also taken upon evaluation to ensure that the fruit were cut within similar firmness ranges. Fruit ripening was expressed as the mean number of days until the fruit ripened and a longitudinal ripening profile was composed.

The following criteria were included when evaluating the fruit upon ripening:

- No. of days to ripen
- Bruising
- Black cold damage
- Lenticel damage
- Dusky browning

- Grey pulp
- Pulpspot
- Vascular browning
- Anthracnose
- Stem end rot.

The physiological and pathological disorders were scored on a scale of 1-3 where 1 depicted a mild and 3 a severe disorder.

RESULTS AND DISCUSSION:

Figure 1 is a representation of the effect that SmartFresh™ has on the external colour of 'Hass' fruit. This photograph was taken upon removal from a 28 day cold storage period in one of the experiments during which certain logistical problems were encountered. The control fruit has started turning black during storage, while the SmartFresh™ treated fruit remained green. This visually exemplifies the ripening inhibition properties of SmartFresh™.

Figure 2 demonstrates the effect of pallet position within the container during the application and storage period on the ripening of 'Fuerte' count 18 fruit. Pallet position did not make a difference. This indicates that Smartfresh™ diffused effectively through the container.

The **number of days required to ripen 'Fuerte'** fruit during the various trials, is displayed in Figure 3. Treatment with SmartFresh™ led to a significant increase in the average **number of days to ripen**, throughout the season. This was true for the count 18 and count 10 fruit. However, the inhibition of ripening was more pronounced in the smaller count 18 fruit than in the bigger count 10 fruit. When comparing the 300 and 500 ppb treatments, it is clear that the higher concentration of Smartfresh™ more drastically inhibited ripening than the lower concentration. Nevertheless, the effect attained with the 300 ppb treatment was still satisfactory.

During the treatment carried out on 25 April, the packhouse capacity was overloaded. Due to insufficient storage space, the treatment pallets were stored in side halls of the loading zones, with no temperature control. Furthermore, only one forklift was available which had to be shared with the packhouse and oil-factory. For this reason, the palletelised fruit stood outside in the sun for several hours. Regardless of these sub-optimal conditions, the 300ppb treatment was still able to retain storage potential. This is a very promising observation, indicating that SmartFresh™ will have a buffering effect against temperature related hick-ups in the cold chain.

The **number of days until ripe** recorded for ‘**Hass**’ fruit is shown in Figure 4. A trend similar to ‘Fuerte’ was observed. However, the Hass fruit, especially the bigger count 12 fruit, reacted less favourably than ‘Fuerte’ to the SmartFresh™ treatment. This might be contributed to the higher metabolic rate of ‘Hass’ fruit. The general effect was nonetheless acceptable and, as will be shown later, very similar to that attained with CA.

The percentage ‘**Fuerte**’ fruit with **greypulp** is portrayed in Figure 5. The untreated fruit showed an increasing prevalence as the season progressed and this trend started earlier and to a greater extend in the bigger count 10 fruit. It is promising to note that the Smartfresh™ treatments led to a significant decrease in the greypulp incidence of, especially, the count 10 fruit. The reduction was more prominent and consistent in the higher dosage treatments (500ppb) of 24 July and 2 August.

The incidence of greypulp in ‘**Hass**’ fruit is portrayed in Figure 6. The prevalence of the disorder was too low to draw any conclusions.

The incidence of **anthracnose** in ‘**Fuerte**’ is represented in Figure 7. As the season progressed, the incidence of the infection increased. It is therefore promising to note that only one SmartFresh™ treatment, (count 10; treated on 31 July), showed a

significantly higher incidence of anthracnose. We expected the lengthening of the storage period to cause more anthracnose infections.

A similar trend was noticed in ‘**Hass**’ (Figure 8). Only one SmartFresh™ treatment showed a significant increase in anthracnose infection (count18; treated on 30 August). This treatment was done at the higher dosage (500ppb) and the ripening period was considerably longer in this specific case. The intensity of the infection was also influenced. With the control, all 16% of infected fruit scored 1. With the SmartFresh™ treatment 16% of the fruit obtained a rating of 1, while 7.4% scored 2 and 3.7% scored 3. Care must therefore be taken not to over extend the shelflife by using too high a dosage. This was also noticed in the laboratory trials conducted during the previous 2 seasons (Lemmer *et al.*, 2002).

The percentage of ‘**Fuerte**’ fruit with **stem-end-rot** is displayed in Figure 9. The control fruit did not show a significant increase in infection towards the end of the season. However, the Smartfresh™ treatments did. This increase was earlier and more prominent in the count 10 fruit and was again caused by the lengthening of the storage period.

With ‘**Hass**’, the early season Smartfresh™ treatment conducted on 5 June led to a significant increase in **stem-end-rot** (Figure 10). In this regard, it must be mentioned that it is common to find a high incidence of **stem-end-rot** infection at the beginning of the harvest window, when the fruit are still relatively immature. This is exacerbated by further lengthening of the storage period. However, the severity of the infection was not influenced

The highest incidence of in stem-end-rot in ‘**Hass**’ was recorded during the late season (2 and 30 August) in count 12 fruit. These treatments were both done at the higher 500 ppb regime and at first glance, may be ascribed to the lengthening of the storage period. However, these two trials also showed the highest incidence of **lenticel damage** (Figure 11) and **bruising** (Figure 12). The preharvest quality of the fruit was obviously poor.

In Table 1, SmartFresh™ is compared with CA. Both methods inhibited ripening to a similar degree in count 12 Hass fruit during both the early (Table 1a) and the late (Table 1b) season. During the early season, no anthracnose occurred in any of the treatments. However, during the late season, both Smartfresh™ and CA caused significant increases in the incidence of anthracnose infection. Both treatments also caused an increase in the incidence of stem-end-rot during the early season. Although the interpretation of the late season data was confounded by discrepancies between the cold room and container data, a similar trend seemed to exist. As mentioned repeatedly, the observed increase in pathological disorders can be contributed to the lengthening of the shelf-life period. This gives the infections more time to develop under favourable conditions.

In Figure 13, the 8 hour exposure period is compared to the 16 hour treatment period. Three SmartFresh™ dosage regimes were used, namely, 300,400 and 500 ppb. From the graph, it is clear that the 8 hour regime was less effective than the 16 hour regime. In case of count 12 fruit, no significant increase was obtained at both the 300 and 400 ppb concentrations when treated for 8 hours. Only the 500 ppb treatment gave a significant increase in shelf life when treated for 8 hours. In case of the smaller count 18 fruit, both the 400 and 500 ppb treatments were effective when applied for 8 hours.

The above results infer that different concentrations of SmartFfresh™ is required for small and large fruit, when treating the fruit for 8 hours. However, the relatively small volumes of count 10-12 fruit packed makes this impractical. Furthermore, the increased dosage needed for the 8 hour regime will have unnecessary cost implications. As the 300 ppb/16hour was effective for both cultivars as well as for small and large counts, this is obviously the better recommendation.

AD HOC LABORATORY TRIALS CONDUCTED DURING 2002:

In addition to the semi-commercial trials described above, two laboratory scaled trials were conducted during 2002. The trials were conducted at Westfalia Estates using the equipment and procedures described by Lemmer *et al.* (2002).

A question often asked is: “Will it be possible to treat avocado fruit in a cool truck while in transit to Cape Town harbour?” This implicates a longer exposure periods

than the above 16 hour recommendation. To answer this question, the fruit were treated with 300 ppb for respectively 16, 24 or 36 hours. The results are shown in Table 2. There was no difference between the treatments in terms of the number of days to ripen (Table 2) or fruit quality (data not shown). This indicates that the lengthened treatment period had no negative effect.

The second experiment aimed to determine what effect a delay between packing and treating has on storage potential of the fruit. To do this, 'Hass' fruit were treated with 300 ppb SmartFresh™ for 8 hours directly after harvest as well as after 3 and 7 days. The results are shown in Table 3. When applied 3 days after harvest, the SmartFresh™ treatment was as effective as when applied directly after harvest. When applied 7 days after harvest, the treatment was slightly less effective and it led to increased pathological disorders (data not shown) which is undesirable.

SUMMARY AND RECOMMENDATIONS:

Prevention of soft landings:

- **Smartfresh™** effectively inhibited the ripening process of 'Hass' and 'Fuerte' under bigger volume **semi-commercial conditions**.
- The increase in storage life is comparable to CA when **Smartfresh™** is applied at optimum dosage.
- The inhibition of ripening is more intense in 'Fuerte' compared to 'Hass'.
- The inhibition of ripening is more intense in the smaller **Count 18** fruit compared to bigger **Count 10-12** fruit.

Physiological disorders:

- Smartfresh™ reduced the incidence of **greypulp** during certain trials.

- The reduction was greater at the 500 ppb concentration than at the 300 ppb concentration.
- The reduction was most noticeable in bigger sized fruit, especially at the end of the season when the incidence of greypulp was at its highest.

Pathological disorders:

- In both Smartfresh™ treated and CA stored fruit the lengthening in days to ripen **does not** influence **anthracnose** infection incidence in the **early season**.
- During the **late season, increased anthracnose** infection incidence sometimes occurred in both Smartfresh™ treated and CA stored fruit.
- Lengthening of ripening period sometimes led to an **increase** incidence of **stem-end-rot** in both CA and Smartfresh™ treated fruit. This was more prominent at the end of the season.
- The increased incidence of pathological disorders associated with the lengthened shelf life is exacerbated by the pre-harvest quality of the fruit.

Dosage and treatment period:

- At this stage, it is recommended that packhouses apply SmartFresh™ to 'Fuerte' and Hass fruit at a concentration of **300ppb for a period of 16 hours**.
- The exposure period may be extended to **36 hours** if it is conducted in a refrigerated truck *en route* to Cape Town harbour.

- The Smartfresh™ is most effective when applied **within 3 days after harvest.**

REFERENCES:

1. Lemmer , D., Kruger, F.J. Malumane, T.R. & Nxudu, Y. **2002.** 1- Methyl cyclopropene: an alternative for controlled atmosphere storage of South African export avocados. *Journal of the South African Avocado Growers' Association*, 25:28-39.