

The Effect of Preshipment Factors on the Market Quality of Fuerte Avocados 1996 Season

GJ Eksteen¹ • J Bezuidenhout² • B Suter³ • R Robinson¹ • N Ray⁴ • S A Rowe⁴

¹*PRECB, P.O. Box 15289, Panorama, 7506*

²*Hans Merensky, P O Box 14, Duivelskloof 0853*

³*SAAGA, P O Box 866, Tzaneen 0850*

⁴*HL Hall & Sons, P O Mataffin 1205*

INTRODUCTION

The European market demands hard avocados without any external and internal disorders. All these characteristics are influenced by horticultural aspects, preshipment handling procedures and voyage conditions.

Handling procedures, voyage conditions and market quality were monitored over six seasons. Present handling and transport procedures are based on this research. Most of the available data and recommendations however are based on the behaviour of Fuerte avocados shipped in ducted containers.

Important aspects confirmed during previous seasons can be summarised as follows:

1. Fuerte avocados older than 28 days between picking and arrival in the market develop more chilling injury (longer low temperature exposure) and were softer than younger fruit, irrespective of optimum post-harvest temperature management procedures.
2. Freshly picked avocados can be transported and shipped warmer than older fruit and will arrive in a firm condition, provided optimum voyage temperatures were maintained.
3. For different age categories of fruit to arrive on the market with firm readings of 30 units and less, the following maximum loading temperature tolerances must apply.
 - Fruit that will be approximately 20 days old on arrival (i.e. so called dead line fruit) can be loaded up to 4°C warmer than the specified optimum holding store intake temperature.
 - Fruit of the medium category that will be approximately 24 days old on arrival at the market, can be loaded up to 3°C warmer than the specified optimum holding store intake temperature.
 - Old fruit that will be older than 28 days old on arrival at the market must not be loaded warmer than 2,0°C warmer than the specified optimum holding store intake

temperature.

A temperature management system to ensure a constant downward trend in pulp temperature reduced the rate of softening during the voyage and drastically reduced the incidence of chilling injury and physiological disorders.

Fruit condition, pre-harvest and post-harvest discharge as well as road transport and voyage temperatures for the 1996 season were again analysed. These results and conclusions are discussed in this report.

PROCEDURES

Evaluation of fruit condition

A total of 528 commercial samples of avocados were monitored from packhouses into the Rungis market in Paris.

Definitions

The following abbreviations are used in the text. Abbreviations used in the statistical analysis tables are given in brackets.

Age Age of the fruit between picking and the event, e.g. in the case of preshipment, fruit age is the number of days between picking and departure of the vessel (AGE).

Black Cold Chilling injury resulting in a brown to black discolouration of the skin. (BLACK-RIPE i.e. at eating ripe stage)

Brown Cold Normally develops after storage and transport i.e. in the market place. (BROWNRIFE i.e. at eating ripe stage).

Dusky Cold Senescent discolouration developing on the skin of Fuerte and sometimes Edranol avocados (DUSKY-RIPE i.e. at eating ripe stage).

Firmo Fruit firmness as measured with a FIRMOMETER. Corresponding fruit firmness readings are as follows: (FIRMOMETER):

Lentidamage External discolouration of mainly the lenticels. This disorder is not related to low temperatures during storage. It is mechanically induced and may develop during storage and transport. (LENTIRIFE - i.e at the eating ripe stage).

Grey pulp Greyish pulp discolouration that develops in the mesocarp of the avocado fruit after a few minutes of cutting the fruit to expose the cut cells to oxygen.

Pulpspot Discoloured spots developing in mesocarp of fruit after cutting.

Other abbreviations used in the text and statistical summaries are:

FIRST TEMP The first return air temperature (RAT) reading obtained after applying cooling in the Holding Store.

HSTEMPIN RAT recorded during initial stages in Holding Store.
HSTEMP OUT RAT recorded during final stages in Holding Store.
HSTOTTIME Total time in hours that container was connected to Holding Store cooling.
HDGHSTIME Date and time container was loaded into the Holding Store.
HDGTEMP Avocado pulp temperature when loaded into the Holding Store.
RYAN Q Air temperatures recorded inside avocado carton on 3rd carton from the top at the door end with a Ryan strip chart recorder.
RUN DEL Fruit quality as measured on arrival at Rungis, Paris.
RUN NEW Fruit quality as measured on arrival at Rungis Paris.
RUNF96 Fruit quality as measured on arrival at Rungis, Paris.
509 Voyage 509 of the HEEMSKERCK
510 Voyage 510 of the WINTERBERG
511 Voyage 511 of the KALAHARI

The abovementioned quality and shipping parameters were correlated with the condition of the avocados on arrival on the Rungis market in Paris. This data was statistically analysed using the STATGRAPHICS computer programme. Analysis of variance, multiple regression and simple correlation techniques were used.

RESULTS AND DISCUSSIONS

It is not the intention to discuss the results in detail, but only to highlight those handling and transport factors that had a statistical significant effect ($P = 0, 05$) on fruit quality.

General aspects affecting avocado fruit quality

- Factors expressing a positive correlation of more than 95% probability.

Fruit age i.e. older fruit resulted in more:

Soft fruit on arrival

Brown cold development

Grey pulp development during transport

Softer fruit was associated with:

An increase in fruit age

An increase in brown cold during marketing

An increase in dusky cold during marketing

An increase in grey pulp during transport

An increase in pulp spot during transport

Other significant positive correlations

Black cold injury with lenticell injury

Dusky cold injury with lenticell injury

Brown cold injury with grey pulp

Grey pulp with dusky cold

Grey pulp with pulp spot

Pulp spot with fruit firmness

Pulp spot with brown cold

Pulp spot with dusky cold

Pulp spot with vascular browning

The data confirms the finding of the 1993; 1994 and 1995 seasons. It is very clear that:

Older and softer fruit developed more quality defects during transport, storage, distribution and marketing. It is also very clear that all the low temperature related defects (cold injury) are very closely interrelated with physiologically induced quality defects.

In practice this means:

- Only fresh fruit must be exported by sea
- Only firm fruit must be exported by sea
- Optimum temperatures must be applied
- Factors expressing a negative correlation of more than 95% probability

Low temperatures

Too low pulp temperatures during container loading results in more chilling injury.

Lower holding store temperatures results in more brown cold injury.

Physiological quality defects

More grey pulp developed with lower holding store loading in / loading out temperatures.

More brown cold development with lower holding store loading in / loading out temperatures.

More brown cold developed with lower initial delivery air temperatures of container vessels.

The data also confirms that too low fruit temperatures, prior to departure of the vessel, resulted in more cold injury and physiological defects. If this data is compared to the findings of the 1993; 1994 and 1995 season, it can be concluded that these negative correlations could only be proved during 1996 because of the overall poorer inherent quality of fruit.

In general avocados softened much faster in 1996 than any of the previous seasons.

More specific handling procedures affecting market quality

The 1996 season was characterised by very severe low temperature related and physiological disorders. Most of these defects however were not completely absent when the avocados arrived on the Rungis and other markets. The disorders however developed very quickly with an increase in severity during subsequent storage and shelf life.

Non-optimum handling and storage conditions as well as overstorage in the overseas markets resulted in unnecessary losses to the exporter.

It can be speculated that most of the physiological disorders were induced by pre-harvest factors. Some of these are a very severe drought (1993 1995) followed by extremely wet and humid conditions throughout the 1996 season and very fast physiological maturation on the trees.

Experience has learned that physiological disorders, such as pulp spot are related to tree 'condition' i.e. overall 'health' condition resulting in balanced vegetative and fruit production.

Definitions of low temperature related disorders such as lenticold, brown cold, black cold, dusky cold etc are very difficult to control. This is especially true when fruit temperatures must be maintained at lower levels to reduce fruit softening and senescence related physiological disorders as was the case during the 1996 season.

The most severe type of cold injury during 1996 was brown cold. This phenomenon was statistically analysed on a South African industry basis.

- Effect of accumulation of containers in the holding store on the incidence of brown cold

Avocados and other refrigerated produce are loaded into ducted containers at a specified temperature prior to arrival of the container ship. The loaded containers are then stored in the holding store and air at the specified temperature is supplied to the container. This accumulation period may not exceed 8 days for avocados which is the intervals between vessel departures (maximum period between picking and departure of the vessel stipulated at 12 days). The data shows very clearly that the longer the period the fruit were accumulated in the holding store, the more brown cold developed in the market place. It must be remembered that this factor also includes the effect of fruit age. It has been proved that the longer the period between picking and marketing

(fruit age), the more brown cold will develop.

The concept of accumulation in the holding store can be broken down into the following factors in an attempt to prevent this phenomenon recurring.

Fruit age. The effect of fruit age on brown cold development was statistically analysed. The regression analysis limits however are so wide that the regression formula % Brown cold = $66,29 + 5,59 (0,88)$ has no practical application to all.

This effect will however have to be studied but in the meantime the commercial practice would be to minimise accumulation periods in the holding store. This however can only be done within the practical limitation of picking, packing, precooling, transport and port handling.

Total time in the holding store. The data in confirms that the total accumulation period in the holding store had a highly significant effect ($P = 0,5$) on the subsequent development of brown cold on avocado fruit.

Production and packhouse handling. The total effect of the two factors were statistically analysed by comparing the incidence of brown cold reported by the different commercial packhouses.

It can be concluded from this data that there was no statistically significant difference in the occurrence of brown cold in fruit packed in the different commercial packhouses. These packhouses are spread throughout the whole of the Northern production areas representing many different situations, and therefore it can be concluded that climatical and soil conditions, maturity, handling, packaging, cooling etc had no effect of the final incidence of brown cold in the market.

This finding again puts the focus on holding store condition such as temperature and relative humidity (RH) management.

Delivery air temperature (DAT). The effects of time in , holding store; DAT while in the holding store (HSOUTIN) and first return air temperature (RAT) recorded by the vessel on recommencement of cooling (FIRSTIN) confirm that the holding store temperature had no effect on the incidence of brown cold. The DAT and RH control and variation in the holding store will have to be re-evaluated. The present practice is to set the holding store DAT at the same value as the shipping DAT.

Relative Humidity. The RH of the cooling air and air velocity should be measured and the effect on low temperature disorders be determined as it was shown that low RH's can aggravate cold injury related defects. Again it can be stated that precooling to a pulp temperature of holding store intake temperature will result in a higher and more stable RH. This should reduce moisture loss that is believed to induce chilling injury.

- **Black cold**

The data on the incidence of black cold was statistically analysed and the results indicate that both accumulation time in the holding store as well as holding store DAT are positively correlated with the incidence of black cold. This confirms the necessity to investigate the cooling procedures whilst the avocados are in the holding store. It can be speculated at this stage that low temperatures are too well maintained during the accumulation period.

Fruit firmness

Fruit firmness and external appearance are major quality criteria. Avocados need to arrive (rock) hard in the market place. The rate of fruit softening is determined by a number of factors, but actual fruit temperature is the most dominating factor.

- **Holding Store condition**

Holding store conditions significantly affected brown and black cold. It was therefore decided to correlate holding store conditions with fruit firmness on arrival in the market place. The data confirms that warmer holding store temperatures resulted in softer fruit. This phenomenon poses a very practical problem because data suggests that the holding store temperature must be controlled slightly warmer than at present to reduce brown and black cold. The practical approach would be to control holding store temperatures at lower levels in order to maintain fruit firmness.

Holding store accumulation period however had no statistical significant effect on final fruit firmness. This confirms that the holding store operation, as applied during the 1996 season, were within the optimum range for effective firmness control, but not for effective control of brown cold.

- **Fruit temperature on arrival in the port**

Many factors affect fruit firmness. In an attempt to minimise the effect of time on season, it was decided to compare the arrival temperatures of avocados with fruit quality in the market place for three successive vessels, i.e. the HEEMSKERCK (509), the WINTERBERG (510), and the KALAHARI (511).

The results of the statistical analysis indicate that fruit shipped on the WINTERBERG (510) arrived significantly softer than fruit shipped under similar temperature conditions on the other two vessels. This is despite the fact that the fruit for the WINTERBERG (510) arrived colder (7,0°C) in Cape Town than the fruit shipped on the other two vessels (7,7°C and 7,9°C).

The data also confirms that there was no statistical difference in shipping temperatures between the three vessels.

It can therefore be concluded that the fast rate of softening that took place in the fruit

shipped on the WINTERBERG (510) was not related to arrival temperatures in Cape Town or shipping conditions during the voyage. It can however be speculated that the faster softening rate of the fruit shipped on the WINTERBERG (510) could be the result of:

- Handling condition prior to arrival in Cape Town conducive to faster softening.
- Post shipment conditions conducive to faster ripening after discharge.

It can be mentioned that the WINTERBERG (510) reported warmer RAT two days after departure from Cape Town than the other two vessels. This despite the fact that the fruit for the WINTERBERG (510) was received colder and that the carrying temperature specifications were the same for all three vessels.

A preshipment condition therefore seems to have contributed most to the faster softening rate observed on fruit shipped in the WINTERBERG (510).

Ryan temperature recording

Many exporters (also some importers) insist on using Ryan temperature recorders in avocado shipments. These recorders are normally installed in an empty avocado box in the 3rd layer from the top of the last pallet to be loaded into a container. Some specific practical problems are experienced, e.g.:

- Air temperature in the warmest area of the container (basically RAT) is recorded and does not reflect the specified DAT to the holding store and the vessel.
- RAT, especially in this position, is not correlated to fruit temperatures and deductions related to quality are therefore very subjective.
- Ryan recorder data is not considered sufficiently accurate by insurance companies should a claim be instituted.

Transport temperature data, as recorded by Ryan temperature recorders, were correlated with final fruit quality indexes.

The 1996 data suggests that Ryan temperature data did not substantiate conclusions on fruit quality.

SUMMARY

Statistical analysis of industry and PPECB temperature and quality data showed the following:

- **Older fruit** softened more and developed more brown cold and grey pulp than fresher fruit.
 - **Fruit softening** was associated with an increase in fruit age and an increase in low temperature related defects.
 - **Holding store conditions** resulted in an increase in brown cold.
 - **Warmer holding store temperatures** resulted in softer fruit in the market whilst

colder holding store temperatures resulted in more black cold development.

- **Actual shipping temperature regimes** had very little or no effect on differences in fruit firmness on arrival. Differences in firmness of fruit shipped on different vessels may be ascribed to less optimum handling and temperature conditions prior to the arrival of the fruit in the port and after discharge.
- **Ryan temperature recorder** data did not reflect fruit quality as a function of temperature.

RECOMMENDATIONS

- **The handling procedures** and temperature requirements followed since 1994 must be applied very strictly. This applies especially to fruit temperature and fruit age.
- **The holding store conditions**, especially RH changes, must be studied to determine the effect on chilling injury and physiological defects.
- Exporters must re-evaluate the use of **Ryan recorders** to indicate fruit quality on arrival in the market.