Effect of Cool-storage Delays after Harvest on the Extent of Ripening during and Fruit Quality after Cool-storage

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ABSTRACT

Sensation and Tommy Atkins mangoes were placed in cool-storage at 12.5°C for 28 days 12, 36, 60 or 84 hours after harvest. The fruits were held at 20°C prior to and after cool-storage. On fruit ripening after cool-storage, shelf-life and various fruit quality attributes were assessed. In Sensation, pulp penetration pressure, pulp colouration, and total soluble solids content were assessed on fruit placement in cool-storage and one week after the commencement of cool-storage.

Shelf-life decreased markedly with the delay in time of fruit placement in cool-storage. In Sensation, ripening rate during the initial period of cool-storage increased with the delay prior to cool-storage. On fruit ripening, the incidence of lenticel damage in Tommy Atkins and Sensation generally increased with the delay prior to cool-storage. The trend was non-significant in Sensation. In this cultivar, taste appeal tended to decrease slightly with the delay prior to cool-storage. A similar trend was not apparent in Tommy Atkins. In Sensation and Tommy Atkins, differences in ground skin colouration, total soluble solids content, pH, pulp colouration and physiological disorder severity relating to treatment were not apparent. In Sensation, differences relating to treatment in disease, blotch and surface scald were not evident. These disorders did not occur in Tommy Atkins. The present study shows that unduly time delays in placing fruits in cool-storage after harvest can result in fruit being soft on arrival at ports and distributors overseas.

INTRODUCTION

Differences in the time taken from harvest until mangoes are placed in cool-storage after packline treatment, sorting and packing were identified by the author as a possible cause for differing outcomes in terms of fruit ripeness and quality after extended cool-storage (sea export of mangoes to Europe). Ripening during transit to the extent of the fruits being soft on arrival is unacceptable, since soft fruits are unsuitable for further distribution due to their reduced tolerance to handling and propensity to rapid deterioration. Degree of ripening during cool-storage and extent of disease manifestation during and after cool-storage were previously shown to be positively correlated (Oosthuyse, 1994).

The aim of the present study was to assess the effect of various delays in time from harvest until fruit placement in cool-storage on the rate of ripening during cool-storage, and shelf-life (time taken for fruit to attain the stage of firm ripeness) and fruit quality after cool-storage.

MATERIALS AND METHODS

Two similar experiments were performed, one using Sensation and the other using Tommy Atkins. Forty 4 kg cartons of mangoes of each cultivar were harvested in the Letsitele Valley during the 1996/97 harvest season. Signs of pulp colouration were evident at the times of harvest.

The fruit of each cultivar were treated identically, except that ripening rate during the initial period of cool-storage was not assessed in Tommy Atkins. The following was performed:

After washing (1% Bi-Prox soap solution), hot-water treatment (5 min. water dip at 50°C), prochloraz treatment (180 ml Omega/100l H_2O ambient dip), and waxing with TAG, the fruits were repacked into their cartons. The treatments (time delays until placement in cool-storage) were randomly allocated to each carton (allocation according to the randomized complete blocks design). Twelve hours after harvest, 10 of the cartons were placed in cool-storage (12.5°C ±0.5°C). The remaining cartons were placed in a laboratory maintained at 20°C (±1°C). Thirty six, 60 or 84 hours after harvest, a further 10 cartons were placed in cool-storage. All of the fruit were put in the same cool-storage room, and remained in cool-storage for the same period of time (28 days).

To assess the extent of ripening of Sensation during the first week of cool-storage, pulp penetration pressure, pulp colouration and total soluble solids content were determined on placement of the fruit in cool-storage and one week after the commencement of cool-storage. Two fruit per carton were removed for evaluation at each of these times.

Pulp penetration pressure was measured with a Facchini FT 327 penetrometer to which the 6 mm plunger was attached. Each mango was first cut through twice; `longitudinally' along the flattened margins of the seed. A measurement was taken from the centre of the exposed pulp of each of the `cheeks' thus obtained. Total soluble solids content

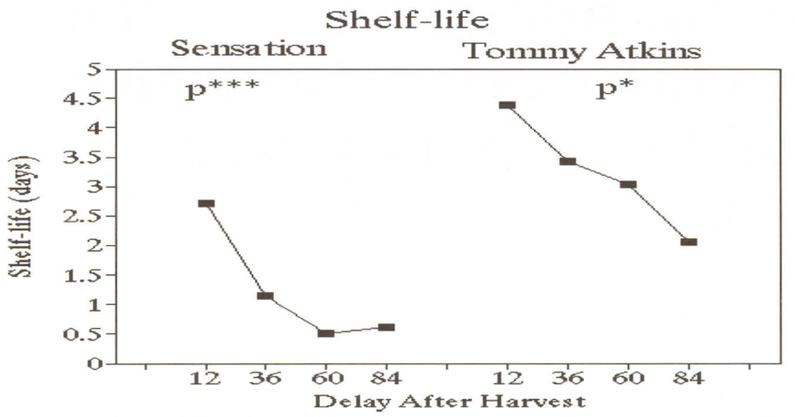

Fig. 1 *Shelf-life of Sensation (left) and Tommy Atkins (right) in relation to the delay in the time of fruit placement in cool-storage after harvest. P^{***} = very highly significant trend ($p < 0.001$); P^{**} = highly significant trend ($p < 0.01$); P^{*} = significant trend ($p < 0.05$); P(ns) = non-significant trend ($p > 0.05$).*

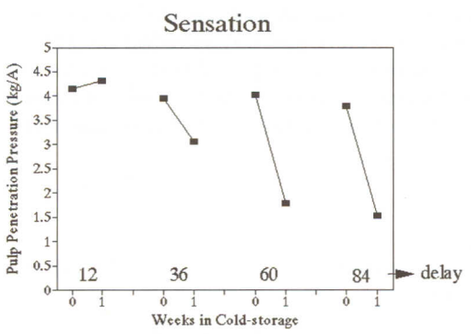

Fig. 2 *Changes in pulp penetration pressure during the first week of cool-storage in relation to the delay in the time of fruit placement in cool-storage.*

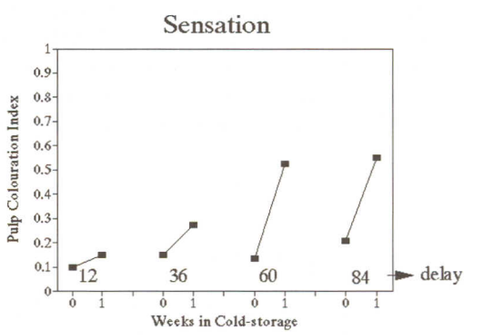

Fig. 3 *Changes in pulp colouration during the first week of cool-storage in relation to the delay in the time of fruit placement in cool-storage.*

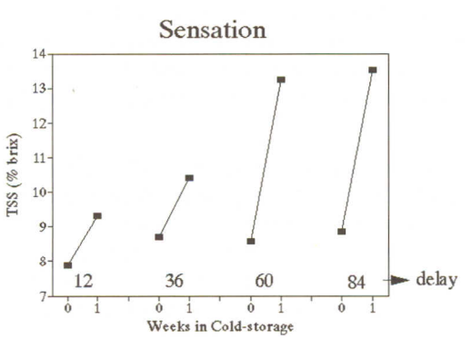

Fig. 4 *Changes in total soluble solids content during the first week of cool-storage in relation to the delay in the time of fruit placement in cool-storage.*

and pulp colouration were measured as stated in what is to follow.

After cool-storage, the fruits were placed in the aforementioned laboratory, following which the degree of softening of each fruit was monitored daily with a densimeter (Heinrich Bareiss, Oberdischingen, Germany). Each fruit was evaluated for quality when it was firm-ripe (densimeter reading of less than 60 and greater than 40 from a non-diseased portion of the fruit). Quality evaluation was performed as follows:

Skin colour in each fruit was rated. A rating of "0" was given when signs of skin colouration were absent, a rating of "1" if a transition to a lighter green was apparent, a rating of "2" if regions of the skin had become yellow but the total area which was yellow was less than the total area which was green, a rating of "3" if regions of the skin had become yellow and the total area which was yellow exceeded the total area which was green, or a rating of "4" if the skin was

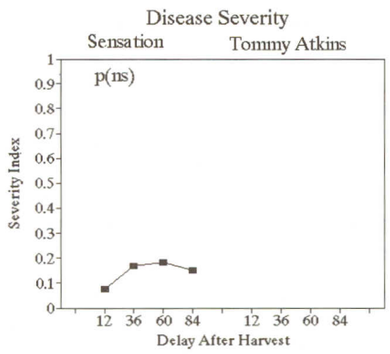

Fig. 5 *Disease in Sensation (left) and Tommy Atkins (right) in relation to the delay in the time of fruit placement in cool-storage after harvest.*

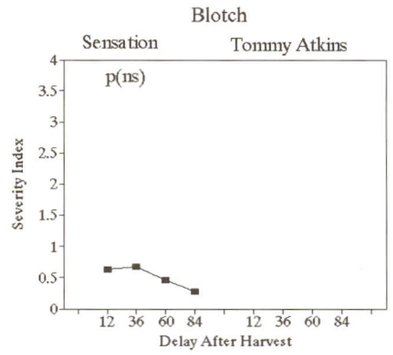

Fig. 6 *Blotch in Sensation (left) and Tommy Atkins (right) in relation to the delay in the time of fruit placement in cool-storage after harvest.*

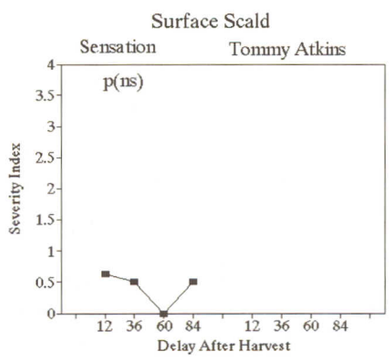

Fig. 7 *Surface scald in Sensation (left) and Tommy Atkins (right) in relation to the delay in the time of fruit placement in cool-storage after harvest.*

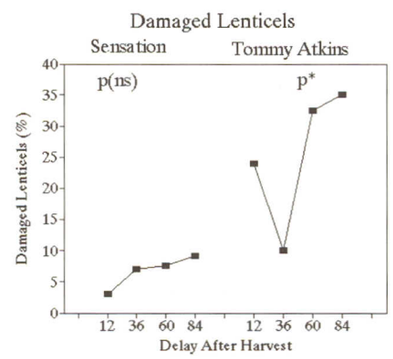

Fig. 8 *Lenticel damage in Sensation (left) and Tommy Atkins (right) in relation to the delay in the time of fruit placement in cool-storage after harvest.*

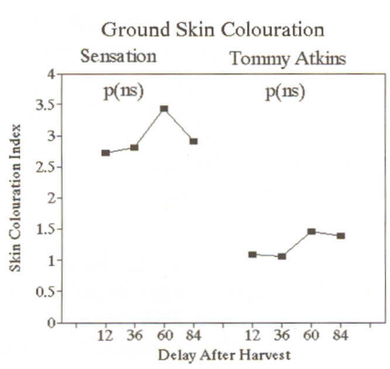

Fig. 9 *Ground skin colouration on ripening in Sensation (left) and Tommy Atkins (right) in relation to the delay in the time of fruit placement in cool-storage after harvest.*

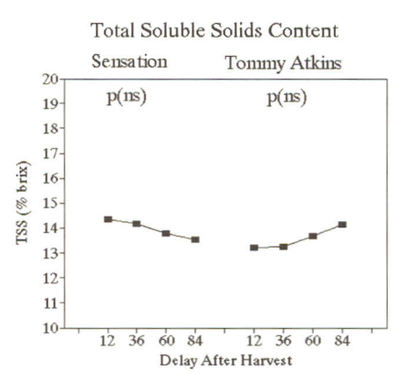

Fig. 10 *Total soluble solids content on ripening in Sensation (left) and Tommy Atkins (right) in relation to the delay in the time of fruit placement in cool-storage after harvest.*

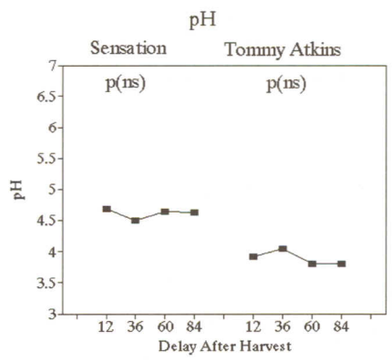

Fig. 11 *pH on ripening in Sensation (left) and Tommy Atkins (right) in relation to the delay in the time of fruit placement in cool-storage after harvest.*

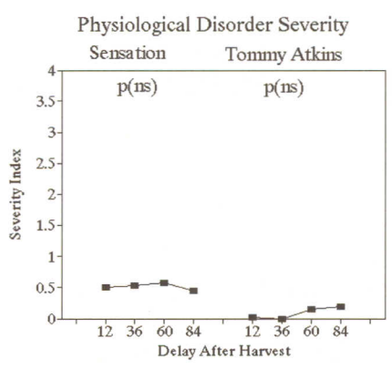

Fig. 12 *Physiological disorder severity on ripening in Sensation (left) and Tommy Atkins (right) in relation to the delay in the time of fruit placement in cool-storage after harvest.*

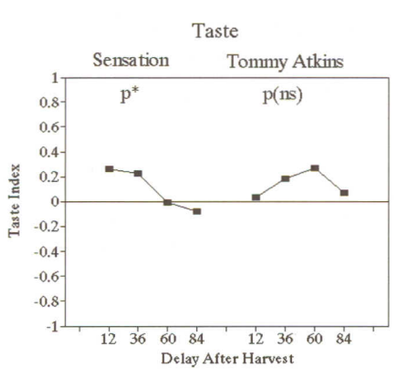

Fig. 13 *Taste on ripening in Sensation (left) and Tommy Atkins (right) in relation to the delay in the time of fruit placement in cool-storage after harvest.*

completely yellow. The skin area covered with red-blush was not considered.

Disease manifestation in each fruit was rated according its severeness. A rating of "0" was given if a fruit was disease free, a rating of "1" if symptoms were present but were localized to a small portion of the fruit's surface, a rating of "2" if approximately 1/3 of the fruit's surface showed symptoms, a rating of "3" if 2/3 of the fruit's surface was affected, or a rating of "4" if the entire fruit's surface was visibly diseased. The diseases occurring were also identified.

Lenticel damage, blotch (green patchiness of skin), pitted spot and surface scald were rated by approximating the percentage of the skin surface over which symptoms could be seen. The percentages designated were either 0, 25, 50, 75 or 100.

To assess internal quality, each was first cut through twice; `longitudinally' along the flattened margins of the seed. In each fruit, juice from the `cheeks' thus obtained was evaluated by measuring its pH (Mettler Toledo 120 pH meter) and total soluble solids content (TSS) (Euromex RF 0232 hand held refractometer), and by assessing its taste.

Taste was rated. A rating of "1" was given if taste was deemed appealing, a rating of "0" if taste was deemed satisfactory but not appealing, or a rating of "-1" if taste was deemed unsatisfactory.

Mesocarp colour, i.e., the degree of colour intensification of the mesocarp from white to yellow/orange, was estimated with the `Zill' colour chart.

Physiological disorder manifestation in each fruit was rated as was disease manifestation, except that the degree to which the mesocarp as opposed to the exocarp (skin) was affected, was taken into account. The disorders occurring were also identified.

In each experiment, there were ten single carton replicates of four treatments. Carton averages were subjected to analysis of variance.

RESULTS

In both Sensation and Tommy Atkins, shelf-life decreased with the delay in time of fruit placement in cool-storage (Fig. 1). In Sensation, shelf-life decreased from an average of between 2.5 to 3 days (placement in cool-storage 12 hours after harvest) to an average of half a day (placement in cool-storage 60 to 84 hours after harvest). In Tommy Atkins, shelf-life decreased from an average of between 4 to 4.5 days (placement in cool-storage 12 after harvest) to an average of 2 to 2.5 days (placement in cool-storage 84 hours after harvest).

In Sensation, ripening rate during the first week of cool-storage, as indicated by changes in pulp penetration pressure, pulp colouration, and TSS during this period, increased markedly with the delay in time of fruit placement in cool-storage (Figs. 2, 3 and 4). Relative to the foregoing changes, differences in pulp penetration pressure, pulp colouration, and total soluble solids content were small on placement of the fruit in cool-storage.

In Sensation, differences in disease, blotch and surface scald severity were not apparent in relation to treatment (Figs. 5, 6, and 7). These disorders were not encountered in Tommy Atkins.

In Tommy Atkins, the incidence of lenticel damage generally increased with the delay in time of fruit placement in cool-storage (Fig. 8). In Sensation, a slight increase was evident. The trend was non-significant, however.

Differences in ground skin colouration, TSS, pH and physiological disorder severity relating to treatment were not apparent in either cultivar (Figs. 9, 10, 11, and 12).

In Sensation, taste appeal tended to decrease slightly with the delay in time of fruit placement in cool-storage (Fig. 13). A similar trend was not apparent in Tommy Atkins.

Differences in pulp colouration relating to treatment were not evident (data not shown), and pitted spot was not encountered in either cultivar.

DISCUSSION AND CONCLUSION

The results clearly reveal that delays in the time of placement of mangoes in cool-storage after harvest can affect the rate of ripening during cool-storage, and thus shelf-life after cool-storage. Unduly delays after harvest until cool-storage might therefore result in fruit being soft on arrival at ports and distributors overseas.

These results are supported by previous research. It was shown that in Zill mangoes, harvested at an advanced stage of maturation, either pre-stored (20°C for 72 h) or placed directly in cool-storage and placed in cool-storage at 11°C, 8°C or 8°C followed by 6°C (cool-storage for 28 days), all of the fruits having been pre-stored softened to the point of eating-ripeness during cool-storage, irrespective of the cool-storage temperature regime adopted. In the fruits placed in cool-storage after pre-storage, the beneficial effect of pre-storage on various quality attributes was offset by the negative effect of an increased incidence of disease and over-ripeness after cool-storage. In this study, direct placement of mature Zill mangoes in cool-storage at 8° was deemed to be the best storage option (Oosthuyse, 1994).

In an experiment where cartons of Kent mangoes were stored at 20°C after packline treatment and packing into cartons, and where carton batches were placed consecutively in cool-storage - the first batch entering cool-storage when hard and green and the last when at the eating-ripe stage -, successive batches showed a marked reduction in the percentage of good quality fruits present after cool-storage for 4 weeks and subsequent ripening at 20°C. This was due to an increase in the proportion of fruits showing signs of disease. It was concluded that to improve the condition of mangoes exported by sea to Europe, fruits should be exposed to ripening conditions on arrival, as opposed to being allowed to ripen somewhat before exportation (Oosthuyse, 1992).

A deterioration in fruit quality in relation to the delays prior to cool-storage was not clearly apparent in the present study. This may have been due to the low incidence of disease, and the relative shortness of the time delays examined.

In light of the present study and in view of the above, it is recommended that mangoes be harvested, treated, sorted and packed in as short a period as possible prior to their placement in cool-storage.

ACKNOWLEDGEMENTS

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